

# **The Muqarnas in Contemporary Art and Epigraphic Design**

Developing technical vision in the design of the muqarnas

Thesis submitted for the degree of  
Doctor of Philosophy  
In  
Graphic Design

By

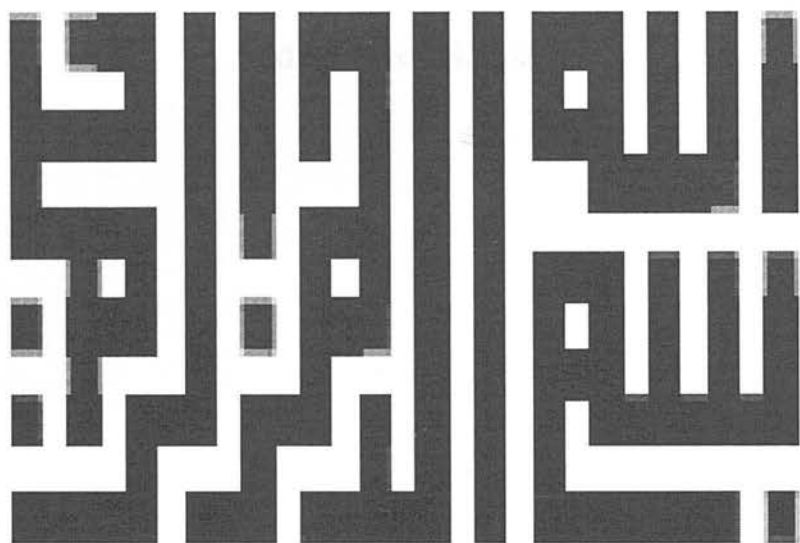
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2010



**In the Name of God Most Gracious, Most Merciful**



## **Declaration**

This thesis my original work and has been composed solely by myself.

Abdalmajeed Sabbagh

## Abstract of Thesis Form

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### Abstract

This thesis is about muqarnas, a type of three-dimensional decorative finishing strip using concave elements. It is a kind of corbel used in Islamic architecture both as a decorative motif and as an enriched block or horizontal bracket. It is generally found under the cornice and above the bed-mould of the Corinthian entablature, and at the same time, it hides the transitional zones between various surfaces (e.g. arches, domes, capitals, windows, ceilings, minarets, mihrabs, minbar, façade). It can take a number of forms and in some circumstances resembles stalactites. It has been applied, artistically, to different materials (e.g. stucco, stone, marble, wood, faience and polychrome) in unique, regularly spaced, geometric arrangements.

The muqarnas is an important feature in Islamic architecture because of its social, cultural and symbolic meanings. The research aim is to critically analyse the muqarnas and to shed light on its genesis, nature and evolution. This will be followed by an attempt to transform the muqarnas to suit modern use without losing its meaning. This study will highlight the importance of providing a simple software program for modelling the muqarnas, relevant to the field of Islamic architecture, epigraphic design and art such that it can be appreciated by contemporary practitioners, especially contemporary viewers, who will find different options in the model (muqarnas blocks) that will allow them to assess alternative designs and have

them ready for use in the form of computerised two-dimensional and three-dimensional drawings.

The thesis begins with a first chapter comprising an introduction to the background, aim, objectives, methodology and the significance of the research. The second chapter is a review of the history of muqarnas and offers an interpretation of all the figures that combine to make the muqarnas types, spatial compositions in interlocking values. The chapter also explores the cultural and compositional units (cube, sphere, wall, columns and arches) and the properties of the organic rules of the muqarnas. The third chapter is an analysis of the proportional order and harmony of each element of the muqarnas units in Islamic architecture. The fourth chapter puts an intellectual and subjective perspective on the properties of the muqarnas, concentrating on structural transformation in Islamic art and architecture using structuralism and associated theories. The fifth chapter reviews the performance of the muqarnas design processing program 'Generator of Muqarnas'. This program can be used to visualise data generated from the blocks of muqarnas, to create a user interface and to convert two-dimensional plans into three-dimensional muqarnas data. The program is based on the original muqarnas types and allows for efficiency of working with materials, textures, colours and light. The final chapter concludes with a brief overview of the significance of the study.

This innovative approach to the modern world will introduce the aesthetics of the muqarnas to a new audience, and rekindle the interest of designers, artists and architects. Using the program they will find alternatives ready for use in the form of computer-generated muqarnas drawings which will help them, as they are easy to use, saving time and effort. The author has made contact with professionals who are interested in using muqarnas and those who are looking to invest and publish the software program when it has been fully developed and tested.

## Dedication

*To all those*

Who contributed to my learning.

*To my parents*

Who brought me up, educated me and made me successful.

To my Father, God bless him, and to my beloved Mother,  
for their endless love and care.

*To my beloved wife Tuba & wonderful children*

Who are my true companions, and who have encouraged me to this stage.

*To all those*

Who encouraged, guided and put me on the right path.

*To them*

I present this work, hoping to express my true faith and loyalty.

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# Table of Contents

Declaration .....	III
Abstract.....	IV
Dedication.....	VI
Acknowledgment .....	VII
Table of content .....	IX
List of Figures .....	XV
Preface .....	XXII
<b>1. Chapter One: Introduction</b> .....	<b>1</b>
1.1. Introduction.....	3
1.2. About the research.....	9
1.3. Research area.....	9
1.4. Research title.....	10
1.5. Research scope.....	10
1.6. Research Question.....	11
1.6.1. Aim.....	11
1.6.2. Objectives.....	12
1.7. Research Methodology .....	12
1.7.1. Literature review.....	12
1.7.2. Investigation.....	13
1.8. The significance of the research.....	13
<b>2. Chapter Two: The origin and evolution of the muqarnas</b> .....	<b>15</b>
2.1. Introduction.....	17

2.2. The seed.....	18
2.2.1. What is a muqarnas? .....	18
2.2.2. Etymology of the muqarnas.....	20
2.3. The emergence of the muqarnas.....	27
2.3.1. Circles to circles shapes.....	30
2.3.2. Circles to squares shapes.....	32
2.4. Instructional and construction arrangement .....	32
2.4.1. Square with circles shape.....	33
2.4.2. Circles with square shape.....	38
2.5. The generative units of the muqarnas.....	41
2.5.1. Evolution of a sphere angle corner.....	45
2.5.2. Evolution of spherical triangles.....	54
2.6. Types of muqarnas.....	57
2.6.1. Plain muqarnas.....	58
2.6.2. Concave composite or Shami muqarnas.....	59
2.6.3. Prismatic composite or Baladi muqarnas.....	61
2.6.4. Stalactites muqarnas.....	62
2.7. Utilisation of muqarnas.....	63
2.7.1. Implementing the muqarnas in arches.....	64
2.7.1.1. Implementing the muqarnas in intrados arch.....	64
2.7.1.2. Implementing the muqarnas in the cascade arch.....	64
2.7.2. Implementing the muqarnas in capitals.....	68
2.7.3. Implementing the muqarnas in domes.....	73
2.7.4. Implementing the muqarnas in minarets.....	80
2.7.5. Implemented the muqarnas in Portals.....	89



2.7.6. Implementing the muqarnas in facades.....	95
2.7.6.1. Implementing the muqarnas in recesses panel.....	96
2.7.6.2. Implementing the muqarnas in cornice.....	100
2.7.6.3. Implementing the muqarnas in cantilever.....	101
2.7.7. Implementing the muqarnas in mihrabs.....	106
2.7.8. Implementing the muqarnas in minbars.....	113
2.7.9. Implementing the muqarnas in furniture.....	116
2.8 – Materials of implementation of muqarnas.....	117
2.8.1. Gypsum (Plaster).....	118
2.8.2. Marble.....	119
2.8.3. Stone.....	121
2.8.4. Wood.....	123
2.8.5. Metal.....	124
2.9. Conclusion of Chapter Two.....	125
<b>3. Chapter Three: The Analysing proportional of the muqarnas</b>	<b>129</b>
3.1. Introduction .....	131
3.2. Organic basis of the proportions of muqarnas.....	132
3.2.1. Simple numerical ratios.....	134
3.2.2. Values of the summation series.....	135
3.2.3. Golden Section.....	136
3.3. The proportions of religious buildings.....	141
3.4. The proportional order in architectural elements.....	146
3.4.1. Arches .....	146
3.4.2. Capitals .....	154

3.4.3. Domes .....	157
3.4.4. Mihrabs .....	161
3.4.5. Minarets.....	163
3.5. The creation of muqarnas and the aesthetic aspect.....	165
3.6. Conclusion of Chapter Three.....	170
<b>4. Chapter Four: The Muqarnas Identity and Structure</b>	<b>172</b>
4.1. Introduction.....	174
4.2. Structuralism.....	175
4.3. Deep structure and surface structure.....	182
4.3.1. Typology.....	185
4.3.2. Form.....	189
4.3.3. Space.....	191
4.3.4. Ornamental.....	195
4.3.5. Laws of composition.....	197
4.3.6. Hierarch.....	200
4.3.7. Order.....	202
4.3.8. Wholeness.....	203
4.3.9. Transformation.....	206
4.4. Identity.....	209
4.5. The meaning of muqarnas.....	211
4.6. Aesthetic and Symbolism of Muqarnas.....	215
4.6.1. Social and cultural dimensions .....	219
4.6.2. Unity.....	222
4.6.3. Cosmology.....	224

4.7. Conclusion of chapter Four.....	226
<b>5. Chapter Five: The contemporary designs of the Muqarnas</b>	<b>229</b>
5.1. Introduction.....	231
5.2. Applying designs using of the software.....	245
5.2.1 - Aim of the software.....	246
5.2.2. Software development methodology .....	246
5.2.3. Software development tool.....	248
5.3. Requirements of Generator of Muqarnas software.....	249
5.4. Designs of Generator of Muqarnas software.....	250
5.5. Developments of Generator of Muqarnas software.....	252
5.6. Testing of Generator of Muqarnas software.....	255
5.6.1. How us of Generator of Muqarnas software.....	255
5.6.2. Accuracy of Generator of Muqarnas software by use AutoCAD.....	262
5.6.3. Usage of the Generator of Muqarnas software.....	270
5.6.3.1. The Generator of Muqarnas from types of muqarnas....	270
5.6.3.2. The Generator of Muqarnas from text Alphabet mold...	273
5.7. Implementations of Generator of Muqarnas software.....	276
5.7.1. Apply Generator of Muqarnas from types of muqarnas.....	276
5.7.2. Apply Generator of Muqarnas from text Alphabet mold...	280
5.7.3. Organizing Generator of Muqarnas view.....	291
5.7.4. Apply Generator of Muqarnas from generated samples...	298
5.7.4. Using Generator of Muqarnas tools.....	306
5.8. Conclusion of Chapter Five.....	307

6. Chapter six: Conclusion and Recommendation 310

6.1. Overview of the Thesis..... 312

6.2. The findings..... 316

6.3. The Generator of Muqarnas program..... 321

6.4 Further research..... 322

6.5. Recommendation..... 326

6.6. Final words..... 327

Bibliography..... 330

Appendixes..... 348

Appendix on: Glossary of Terms ..... 349

Appendix two: The chronology of existing muqarnas ..... 357

Appendix three: Case study... .. 359

## List of Figures

### Chapter Two:

Figure (2.1)	Squats, for a total body workout.	Al-Benaa Architectural Magazine, Vol. 2, (1987).	22
Figure (2.2)	Stalactites, which hang like icicles from the ceiling	Available from: < <a href="http://www.en.wikipedia.org/wiki/Stalactites">http://www.en.wikipedia.org/wiki/Stalactites</a> > [Accessed 8, May, 2006].	23
Figure (2.3)	The three-dimensional geometry of a honeycomb cell.	Available from:< <a href="http://www.en.wikipedia.org/wiki/Honeycomb">http://www.en.wikipedia.org/wiki/Honeycomb</a> ,> [Accessed 8,February, 2007]	24
Figure (2.4)	The three-dimensional geometry of a honeycomb cell.	Ibid.	24
Figure (2.5)	The constructional technique of the dome.	Lewcock,. (199, p.140-141)	27
Figure (2.6)	Quadripartite roof showing how Bricks are laid.	Ibid, p.141	28
Figure (2.7)	Dome on squinch.	Creswel, K. A. C. (1940).	29
Figure (2.8)	Dome on cylindrical projection. A circular on circular shape.	Shafie, (1970)	30
Figure (2.9)	The Treasury of Atreus.	Janson, (1977)	31
Figure (2.10)	Plan of the Pantheon, Rome.	Available from: < <a href="http://www.en.wikipedia.org/wiki/Pantheon%2C_Rome#Ancient">www.en.wikipedia.org/wiki/Pantheon%2C_Rome#Ancient</a> ,> [Accessed 19, July, 2006].	31
Figure (2.11)	Circular dome rest on square.	Shafie F. Op. cit., and < <a href="http://en.wikipedia.org">en.wikipedia.org</a> >	32
Figure (2.12)	Structure of Squinch.	Available from :< <a href="http://www.pitt.edu/~medart/menuglossary/INDEX.HTM">http://www.pitt.edu/~medart/menuglossary/INDEX.HTM</a> > [Accessed 1, May, 2006].	33
Figure (2.13)	Draw squinch two and 3damnation.	Ibid, Squinch, and anther figure draw by author.	34
Figure (2.14)	Firuzabad.	Available from:< <a href="http://www.en.wikipedia.org/wiki/Firuzabad">www.en.wikipedia.org/wiki/Firuzabad</a> ,> [Accessed 6, july, 2006]	35
Figure (2.15)	Ukhaydir Palace, in Iraq.	Available from: < <a href="http://www.nahrain.com/d/pic/history">www.nahrain.com/d/pic/history</a> > [Accessed, 9, May, 2006].	36
Figure (2.16)	Dome of Imam Dur in Samarra.	Available from:< <a href="http://www.oberlin.edu/art/images/art109/78.JPG">http://www.oberlin.edu/art/images/art109/78.JPG</a> Accessed, 2009.	37
Figure (2.17)	Structure of Pendentive.	Available from: :< <a href="http://www.pitt.edu/~medart/menuglossary/INDEX.HTM">http://www.pitt.edu/~medart/menuglossary/INDEX.HTM</a> > [Accessed 3, May, 2007].	38
Figure (2.18)	Cross section of the interior of Hagias Sophia.	Available from < <a href="http://en.wikipedia.org/wiki/Pendentive">http://en.wikipedia.org/wiki/Pendentive</a> > [Accessed, November, 2007].	39
Figure (2.19)	The muqarnas is used in order to hide the hard edges.	Lewcock, R. op, cit., p.142	42

Figure (2.20)	Develop muqarnas structure in the corner.	Ibid, p.142.	43
Figure (2.21)	Zumurrud Khatoun tomb and inside.	Zumurrud Khatoun tomb, Available from:< <a href="http://www.atlastours.net/iraq/khatouns_tomb.jpg">http://www.atlastours.net/iraq/khatouns_tomb.jpg</a> > [Accessed 15, October, 2006].	45
Figure (2.22)	Al-Hakim and Al-Azhar Mosque, muqarnas plan.	Lamie, S. M.	47
Figure (2.23)	Faraj Bin-Barquque and Imam al-Jaafari	Takahash, S. (2004) Available from: < <a href="http://www.tamabi.ac.jp/idd/shiro/muqarnas/data">http://www.tamabi.ac.jp/idd/shiro/muqarnas/data</a> > [Accessed 15, November, 2005]. And Tabbaa, (2002).	48
Figure (2.24)	Increasing layers of muqarnas in the Ottoman architecture	Ibid.	49
Figure (2.24)	Masjid-I Jāmi and plan.	Ibid.	50
Figure (2.25)	Masjid-i-shah and scale.	Ibid.	51
Figure (2.26)	Nur Al-Din dome.	Available from:< <a href="http://www.khayma.com/mehrab/English/building_services.htm">http://www.khayma.com/mehrab/English/building_services.htm</a> > [Accessed 30, April, 2007].	52
Figure (2.27)	Al-Nuri mosque.	Ibid.	53
Figure (2.28)	Ukhaydir Palace from inside.	Ibid.	53
Figure (2.29)	Spherical triangle (Pendentive).	Spherical, Available from:< <a href="http://www.answers.com/spherical-angle">http://www.answers.com/spherical-angle</a> > [Accessed 1, May, 2007].	54
Figure (2.30)	Qusayr 'Amra	Qusayr Amra, Available from:< <a href="http://www.discoverislamicart.org/images/sample.pdf">http://www.discoverislamicart.org/images/sample.pdf</a> > [Accessed, October, 2007].	56
Figure (2.31)	The Hammam al-Sarakh	Ibid.	56
Figure (2.32)	The muqarnas types	Draw by the author	58
Figure (2.33)	The plainer muqarnas	Draw by the author	59
Figure (2.34)	Shami muqarnas	Draw by the author	61
Figure (2.35)	Baladi muqarnas	Draw by the author	62
Figure (2.36)	Cascade of stalactite muqarnas	Draw by the author	62
Figure (2.37)	Wall-mounted muqarnas	Draw by the author	63
Figure (2.38)	The intrados arch of the muqarnas	Paccar, (1981).	65
Figure (2.39)	The intrados arch of the stalactites vaults in Morocco	Ibid.	65
Figure (2.40)	The suspension muqarnas arch	Nazif, (1989).	66
Figure (2.41)	The suspension arch of stalactites vaults in North Africa	Paccar, A. Op. cit.	67
Figure (2.42)	Octagonal-body columns with one row on the muqarnas capital	Nazif, A. S. Op. cit	68
Figure (2.43)	Cylindrical-body columns with one row on the muqarnas capital	Ibid.	69
Figure (2.44)	Octagonal-body columns with two rows on the muqarnas capital,	Ibid.	69
Figure (2.45)	Cylindrical-body columns with two rows on the muqarnas capital	Ibid.	69
Figure (2.46)	The muqarnas capital of al-Hambrā palace	Paccar,. Op. cit.	70
Figure (2.47)	The muqarnas capital of the Holy mosque, in Makkah	Nazif, Op. cit.	72
Figure (2.48)	The muqarnas capital in the corner	Available from: < <a href="http://www.archnet.org">http://www.archnet.org</a> > [Accessed 10, November, 2006].	72

Figure (2.49)	Domes Faraj Ibn-Barqūuqe in Egapt	Ibid.	74
Figure (2.50)	Domes of Süleymaniye and Sultan Ahmet in Istanbul	Ibid.	75
Figure (2.51)	The muqarnas in squinch at domed room	Ibid.	76
Figure (2.52)	The dome of Friday mosque in Iran	Ibid.	77
Figure (2.53)	The Arab Room in the Herbert Tower in Cardiff Castle	Ibid.	80
Figure (2.54)	Minarets of the Qairouan mosque and the al-Hambrā palace	Ibid.	81
Figure (2.55)	The mosque of Ahmad Ibn Tūlūn, in Cairo.	Ibid.	82
Figure (2.56)	Sultan al-Nāṣir Muhammad Ibn Qalāwūn, in Cairo	Ibid.	84
Figure (2.57)	The mosque of Sultan Hassan, in Cairo	Available from: < <a href="http://www.discoverislamicart.org/images/books/7/en/5/sample.pdf">http://www.discoverislamicart.org/images/books/7/en/5/sample.pdf</a> > [Accessed, 1, July, 2009].	85
Figure (2.58)	The Sultan Faraj Ibn Barqūq in Cairo	Available from: < <a href="http://www.archnet.org">http://www.archnet.org</a> > [Accessed 19, November, 2006].	86
Figure (2.59)	The Kalyān mosque in Bukhara and Gunbad-I-Qābūs in Iran.	Ibid.	87
Figure (2.60)	The Sultan Ahmet mosque in Istanbul.	Available from: < <a href="http://www.sacred-destinations.com/turkey">http://www.sacred-destinations.com/turkey</a> > [Accessed 9, May, 2009].	88
Figure (2.61)	The minarets of the Holy mosque in Makkah and Prophet mosque in Medina.	Available from: < <a href="http://www.djibnet.com/photo/54809185-holy-mosque-mi">http://www.djibnet.com/photo/54809185-holy-mosque-mi</a> > [Accessed 30, Aprial, 2007].	89
Figure (2.62)	Portals of Jawsaq al-Khāqānī, in Sāmarrā, in Iraq.	Available from: < <a href="http://www.archnet.org">http://www.archnet.org</a> > [Accessed 19, November, 2006].	91
Figure (2.63)	The Madrasa of Iljāy al-Yūsufī and Khān al-Khalīlī in Cairo.	Available from: < <a href="http://www.flickr.com">http://www.flickr.com</a> > [Accessed 11, November, 2007].	92
Figure (2.64)	The mosque of Amir Bashtāk and Sultan Hasan portal in Cairo.	Available from: < <a href="http://www.img.photobucket.com/Egypt">http://www.img.photobucket.com/Egypt</a> > [Accessed 10, May, 2007].	93
Figure (2.65)	The portal of Masjid-I-Jami in Yazd, and in Isfahan, in Iran.	Available from: < <a href="http://www.islamicity.org">http://www.islamicity.org</a> > [Accessed 19, May, 2007].	95
Figure (2.66)	The types of the recess panels of muqarnas (A- E)	Nazif, Op. cit.	97
Figure (2.67)	The palace of Ālī Qapu in Isfahan.	Available from: < <a href="http://www.torkzadeh.com/ali_qapu">http://www.torkzadeh.com/ali_qapu</a> > , > [Accessed 1, June, 2008].	99
Figure (2.68)	The recess panel of muqarnas, in Morocco	Castera, (1999).	100
Figure (2.69)	The types of the cornices of muqarnas (A –C)	Nazif, Op. cit	101
Figure (2.70)	The types of cantilever muqarnas (A-I).	Nazif, Op. cit	103
Figure (2.71)	Azhar mosque	Available from: < <a href="http://www.coulouris.net/Al-Azhar/mosque">http://www.coulouris.net/Al-Azhar/mosque</a> > , > [Accessed 20, June, 2008].	108
Figure (2.72)	The mihrab of Ash'kali Khan mosque and the Kartā'ay madras'a	Takahash, op. cit.	109
Figure (2.73)	The Ūluo-Jāmī, in Bursa	Ibid.,	110

Figure (2.74)	Hasan-keyf in Call mosque	Ibid.,	111
Figure (2.75)	The mihrab Lutfallah, in Isfahan.	Mihrab, Available from:< <a href="http://www.islamicarchitecture.org">http://www.islamicarchitecture.org</a> > [Accessed, 2,July, 2007]	112
Figure (2.76)	The mihrab of Tāj Mahal, in India	Mihrab, Available from:< <a href="http://thundafunda.com/2/countries/India/download/In">thundafunda.com/2/countries/India/download/In</a> > [Accessed, 2,October, 2007]	112
Figure (2.77)	The minber of the <i>Aqsa</i> mosque in Jerusalem and minber view	Minber, Available from:< <a href="http://td.yimg.com/us.yimg.com/p/ap/20070201/capt.jrl">td.yimg.com/us.yimg.com/p/ap/20070201/capt.jrl</a> > [Accessed, 15,May, 2007]	114
Figure (2.78)	The minber of the mosque of Sultan Hassan, in Cairo.	Available from:< <a href="http://www.discoverislandart.org/images/books/7/en/5/sample.pdf">http://www.discoverislandart.org/images/books/7/en/5/sample.pdf</a> > [Accessed, 1,Jun, 2007]	115
Figure (2.79)	Table and ceiling decoration by muqarnas	Paccar, Op. cit.	116
Figure (2.80)	Ceiling decoration by muqarnas	Ibid.	116
Figure (2.81)	Assembling muqarnas marble in make mihrab.	Al-Bana Magazien, Op. cit.	120
Figure (2.82)	The artisan carving muqarnas stone	Paccar, Op. cit.	121
Figure (2.83)	Construction wood of muqarnas detail at the lap.	Ibid.	124
Figure (2.84)	The metal lantern designs and door designs of muqarnas	Ibid.	125

### Chapter Three:

Figure (3.1)	Rectangle ratio.	El-Said. (1976).	133
Figure (3.2)	The ratio a:b is equal to $1:\sqrt{2}$ (squareroot2)	Ibid.	133
Figure (3.3)	Simple ratios	Scot, R. G. (1940).	135
Figure (3.4)	The ratio of summation series	Ibid., p. 55	136
Figure (3.5)	Golden Section	Bradbury, (1981).	137
Figure (3.6)	Space Requirement for a prayer in the mosque	Hazem, (1999) Magazine, Vol.1 Issue No.1, p.67.	142
Figure (3.7)	The proportions of Sultan Hassan Mosque	Emin, (1987).	143
Figure (3.8)	The proportions of Sultan Baroque Mosque.	Ibid.	145
Figure (3.9)	The Holy Mosque Arch, in Makkah and Kairouan Arch, in Tunisia	Nazif, Op. cit., p.200	148
Figure (3.10)	Arch in the Holy Mosque in Makkah	Ibid.	149
Figure (3.11)	The axial point of the pointed arch in each muqarnas	Ibid.	151
Figure (3.12)	Column with muqarnas in the Holy Mosque in Makkah	Ibid	156
Figure (3.13)	Capital of the muqarnas in the Holy Mosque in Makkah	Bin Laden Office, (2004)	157
Figure (3.14)	The dome of the Two Sisters Hall in the Alhambra Palace in Granada	Paccar, Op. cit.	158
Figure (3.15)	The proportional of dome of Sultan Barqūque Mosque	Emin, op. cit	159
Figure (3.16)	Mihrab of al-Kha'ci'alki	Ghalib, op. cit., p.325	163
Figure (3.17)	The minaret of Sultan al-Ghūrī Mosque	Emin, op. cit	164
Figure (3.18)	The minarets of Sultan al-Ghūrī and Sultan Faraj Ibn Barqūq mosques	Ibid.	165



#### Chapter Four:

Figure (4.1)	Triangle with some repeat geometric designs	By the author	191
Figure (4.2)	Manifest and Hidden	Nader Ardalan & Laleh Bakhtiar, (1973)	192

#### Chapter Five:

Figure (5.1)	Types of unit-surface	Yaghan (2002)	233
Figure (5.2)	Horizontal and vertical joint	Ibid	233
Figure (5.3)	Unit-surface plan	Ibid	233
Figure (5.4)	The plan of roof patch, layer and layer-line	Ibid	234
Figure (5.5)	The example of assembling the unit of muqarnas as whole building and single column.	Ibid	234
Figure (5.6)	The example of single cornice and portal A - B	Ibid	235
Figure (5.7)	View from underneath of portal section at Sultan Han Kayseri (1232–36)	Hamsen and Jungblut (2007)	236
Figure (5.8)	How they can be combined in a row	Ibid	236
Figure (5.9)	Cell and intermediate element with upward directions	Ibid	237
Figure (5.10)	Example of cell of staircase plan	Ibid	237
Figure (5.11)	Entrance portal of the Medrese in Kayseri	Ibid	238
Figure (5.12)	Portal of <i>Arslanhane Camii</i> in Ankara (1290) and its reconstruction	Ibid	238
Figure (5.13)	The plane projection of a simple element is a basic geometrical form.	Dold (2003).	239
Figure (5.14)	The animation of a basic geometrical shape	Ibid	240
Figure (5.15)	Correlating plan	Ibid	240
Figure (5.16)	Correlating plan	Ibid	240
Figure (5.17)	The <i>module</i> of the muqarnas elements construction	Ibid	241
Figure (5.18)	The <i>module</i> of the muqarnas elements with chart composition	Ibid	241
Figure (5.19)	The muqarnas material images.	Takahashi (2000)	242
Figure (5.20)	Waterfall Model	Gary, (1999)	247
Figure (5.21)	Flow-Charts plan of the Generator of Muqarnas software	Draw by the programmer.	250
Figure (5.22)	Blocks model of muqarnas on spherical space	Draw by the author	252
Figure (5.23)	Interface window of Generator of Muqarnas program	Ibid.	256
Figure (5.24)	The mine-screen of Generator of Muqarnas program	Ibid.	257
Figure (5.25)	Display Research menu-list	Ibid.	258
Figure (5.26)	Display Muqarnas Types	Ibid.	260
Figure (5.27)	Display Muqarnas Generator	Ibid.	262
Figure (5.28)	Display Help	Ibid.	263
Figure (5.29)	Open AutoCAD Generator Sample	Ibid.	264
Figure (5.30)	Polar M.G or Rectangular M.G	Ibid.	265
Figure (5.31)	Cylindrical Assembly	Ibid.	265
Figure (5.32)	Viewpoint Presets from VP dialog box	Ibid.	265
Figure (5.33)	Available Material in Drawing from Assign	Ibid.	267

	Material		
Figure (5.34)	Select Image File and Files of type	Ibid.	268
Figure (5.35)	Render	Ibid.	269
Figure (5.36)	SHAMI types of muqarnas.	Ibid.	271
Figure (5.37)	BALDI types of muqarnas.	Ibid.	272
Figure (5.38)	Alphabet Mold I	Ibid.	273
Figure (5.39)	Name of Alphabet Mold I	Ibid.	273
Figure (5.40)	Assembling of Alphabets of Mold I	Ibid.	274
Figure (5.41)	Alphabet Mold II	Ibid.	274
Figure (5.42)	Meme of Alphabet Mold II	Ibid.	275
Figure (5.43)	Assembling of Alphabets of Mold	Ibid.	275
Figure (5.44)	Apply Generator Muqarnas from types of muqarnas	Ibid.	277
Figure (5.45)	SHAMI types of muqarnas A-C	Ibid.	278
Figure (5.46)	BALDI types of muqarnas A-C	Ibid.	279
Figure (5.47)	Mine-Screen of Alphabet Mold I	Ibid.	280
Figure (5.48)	Create muqarnas model from 1 and 2	Ibid.	281
Figure (5.49)	Create muqarnas model from 1, 2 and 4	Ibid.	281
Figure (5.50)	Create muqarnas model from 1, 2 and 3	Ibid.	282
Figure (5.51)	Create muqarnas model from 1, 2,3 &7	Ibid.	282
Figure (5.52)	Mine-Screen of Alphabet Mould II	Ibid.	283
Figure (5.53)	Create muqarnas model from f, f, f, f, f.	Ibid.	283
Figure (5.54)	Polar M.G or Rectangular M.G	Ibid.	284
Figure (5.55)	Cylindrical Assembly	Ibid.	285
Figure (5.56)	Cylindrical Assemble example	Ibid.	285
Figure (5.57)	Example of creation muqarnas from cylindrical assemble.	Ibid.	286
Figure (5.58)	Viewpoint Presets from VP dialog box	Ibid.	287
Figure (5.59)	The view after set angles and using Realistic and Conceptual	Ibid.	287
Figure (5.60)	Applying Material to Objects	Ibid.	288
Figure (5.61)	Materials performance	Ibid.	289
Figure (5.62)	control the material object from AutoCAD dialog boxes	Ibid.	289
Figure (5.63)	Apply Material to object	Ibid.	290
Figure (5.64)	Rendering and object information	Ibid.	290
Figure (5.65)	Deferent Rendering and object information	Ibid.	291
Figure (5.66)	ARRAY dialog box	Ibid.	292
Figure (5.67)	ARRAY dialog box in Auto CAD	Ibid.	293
Figure (5.68)	Array to select image	Ibid.	293
Figure (5.69)	Angle of array	Ibid.	294
Figure (5.70)	Hidden angle of array	Ibid.	294
Figure (5.71)	The realistic image vision	Ibid.	295
Figure (5.72)	Orbit and Zoom for brings the entire drawing into view	Ibid.	296
Figure (5.73)	Sample view of 2D or 3DWire frame, 3DHidden, Realistic and Conceptual A – D.	Ibid.	297
Figure (5.74)	Generated sample I	Ibid.	298
Figure (5.75)	Generated sample I from deferent views mirror and Array	Ibid.	299
Figure (5.76)	The plan of two units from deferent views.	Ibid.	299

Figure (5.77)	The plan of three units from deferent views.	Ibid.	300
Figure (5.78)	The plan of five units from deferent views.	Ibid.	300
Figure (5.79)	Generated sample II	Ibid.	301
Figure (5.80)	Generate sample II in angle of 30 degree.	Ibid.	301
Figure (5.81)	Generate sample II in flat grade	Ibid.	302
Figure (5.82)	Generate sample II in mihrab and portal.	Ibid.	302
Figure (5.83)	Generate sample II in dome.	Ibid.	303
Figure (5.84)	Generate sample II in dome from 3D hidden and conceptual.	Ibid.	303
Figure (5.85)	Generated sample II	Ibid.	304
Figure (5.86)	Generate sample III raised-out of muqarnas, 3D hidden and conceptual.	Ibid.	304
Figure (5.87)	Generate sample III deep-set of muqarnas, 3D hidden and conceptual.	Ibid.	305
Figure (5.88)	Using the view tools of the program	Ibid.	307

## **Chapter six:**

Figure (6.1)	Cosmological model according to the <i>hadith</i> of the Mi'raj	Draw by the author	319
Figure (6.2)	Samples creation from Generator Muqarnas	Ibid.	324

## Preface

Throughout this thesis the following conventions were used regarding Qur'anic verses, Arabic transliteration, the chronology of existing muqarnas and the software programming of the Generator of Muqarnas.

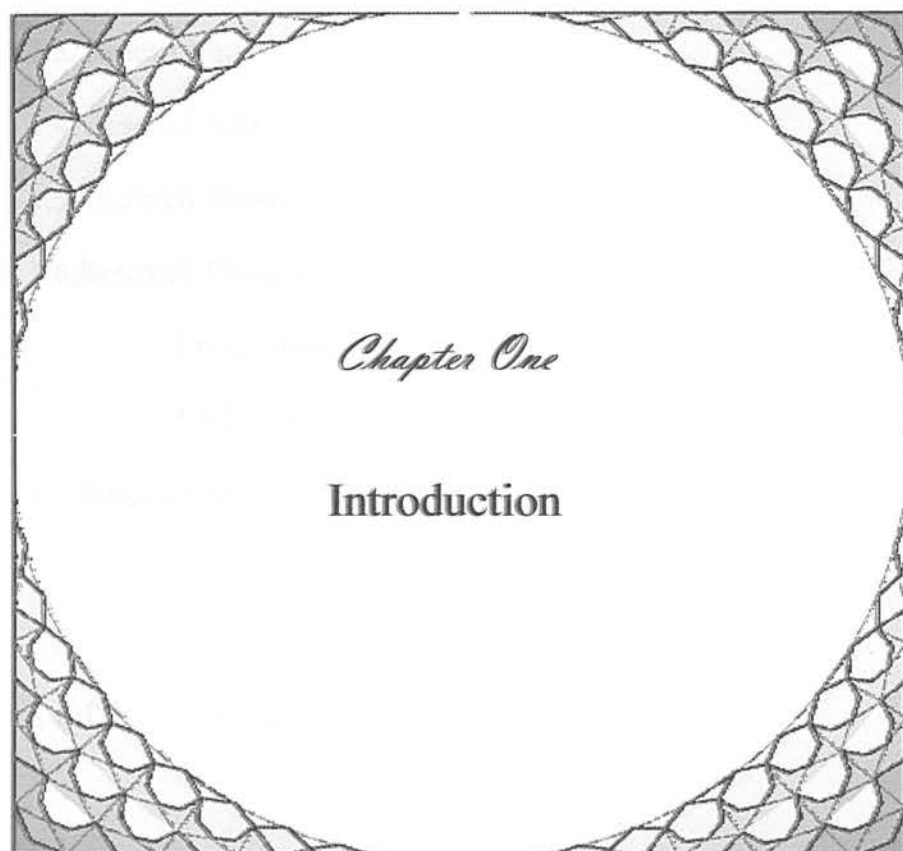
All verses quoted from the Holy Qur'an in the thesis are from The Noble Qur'an, English Translation of the Meaning and Commentary, published by King Fahd Complex for the Printing of the Holy Qur'an, *Al-madinah* KSA in the year 1997. For the Qur'anic citations, the *Sura* number is given first, followed by a colon and the verse number(s), all between brackets. For example, (The Holy Quran, 14:23–29) means that these Qur'nic verses are a translation obtained from the previous source from *Sura* 14, and the verses are 23 to 29.

The system of Arabic transliteration used is an attempt to adopt the simplest and best way possible to convey the nearest pronunciation. Several systems were referred to, but the main reference was the transliteration system described in the International Journal of Middle Eastern Studies.

The chronology of existing muqarnas as the vision of the technical influences of social, cultural and Islamic architecture was derived from historical resources of the muqarnas. However, at the end of the thesis there are two appendices describing the vision and history of the muqarnas, which represent the period from the eleventh century until the present.

Lastly, the research project model of the 'Generator of Muqarnas' program was designed using three programming languages as follows:

- Microsoft Visual FoxPro: a database language used to manage the muqarnas analysis to database. It uses process instructions to set up the various muqarnas structures.
- VBA (Visual Basic for Application): a compact language in the AutoCAD program, used to develop and automate the AutoCAD drawn and design.
- Auto Lisp: a programming language in the AutoCAD program, used to develop draw and design.



## **Chapter One: Introduction**

1.1. Introduction.

1.2. About the research.

1.3. Research area.

1.4. Research title.

1.5. Research scope.

1.6. Research Question.

1.6.1. Aim.

1.6.2. Objectives.

1.7. Research Methodology.

1.7.1. Literature review

1.7.2. Investigation

1.8. The significance of the research.

## **Introduction**

Islamic architecture is distinguished by a unique artistic characteristic, whether in its religious or in its civic context, that serves the Muslim community. At the same time when architectural requirements were structural and variational, the muqarnas was considered to be qualitative in the context of art, and was viewed as the foundation of other artistic fields, for example, decoration. At the same time, architecture is revealed as the mother of all art. This reflection establishes the general relationship between architecture and art, and that unity and depth are evident in the design of the muqarnas can be identified as being a link between Islamic architecture and art.

The clarity, degree and the extent of the organic connection between Islamic architecture and the arts are reflected in the formation of the architectural elements themselves. The muqarnas is a phenomenon that is part of the structure and decorative finishing strip and its features and ornamentation. It has deep roots in all aspects of Muslim art, as an architectural feature, decorative motif, cultural expression and aesthetic, and symbolic meaning in an enriched block or horizontal bracket, adding to the appreciation of the quality of the environment. It is an Islamic architectural element with a structural function, and it is also a shaped ornamental element which controls, to a great extent, the form of the Islamic building and gives it its distinct characteristics (El-Basha, 1965). The muqarnas embodies the unity between architecture and ornamental aesthetics in Islamic art, it could be used both as an architectonic form, because of its relationship to vaults, and as an applied ornament, because its depth could be controlled.



This study of the muqarnas recognises that, fundamentally, the display of its aesthetics in rich spatial forms, and of its ornamental format, has derived from Seljuk and Mamluke models and Andalusian and Ottoman examples. This research intends to show that the muqarnas is a key reference point from an architectural, design, practical and philosophical points of view, and the author will examine its identity and structural considerations. This study will also consider the muqarnas in contemporary art and design, and through this analysis, and by uncovering the 'lost' secrets of its geometrical details, the author proposes that digital technology can replicate the muqarnas and integrate it into software which would aid its use by designers, engineers and architects in interior and exterior design, and allow teaching about its decoration to occur in the applied arts.

The muqarnas is an Islamic innovation used as a means of exploring the cultural and compositional units (cube, sphere, wall, columns and arches) of buildings and other structures. This Islamic ornamentation is an expression of Islamic artistic creativity, and it has various roles in design as a complex geometric interlacing of components, producing a three-dimensional surface using concave elements. The practical importance of the muqarnas is evident by its presence in a large variety of architectural structures, including: arches, capitals, domes, minarets, mihrabs, minbars, exteriors and interiors, which are distinct from its ornamental uses. The other importance of the muqarnas is through the multiplicity of its forms, types and the organisation of its parts and proportion, in keeping with architectural entities. Its geometric formation represents a pure beauty and bestows Islamic architecture with symmetry, in harmony with the aesthetic proportionality of all the components in the building, and their various possibilities in terms of the contiguity and relations that attract the play of shadow and light on these forms.

The scope of this study, therefore, is to discover as much as possible the intentions and influences underlying the muqarnas. A computer program for designing and visualising the muqarnas will be a significant contribution to the design process and will influence the way people create the muqarnas and maintain its role. There has been extensive interest in the study of muqarnas as a design from an objective point of view, with consideration given to building on traditional design elements using scientific technology.

The study is focused on six key aspects of the muqarnas: the **first** aspect comprises an introduction to the research background, aim, objectives, methodology and the significance of the research.

The **second** aspect, the theoretical, will explore the cultural and intellectual properties of the organic rules of the muqarnas. It will focus on its architectural aggregation and the formal principles of artistic composition applied in the ornamental patterns of Islamic art, sourcing both the physical forms and the conceptual vocabulary of meaning and symbolism used in the architecture. Another aspect, the spatial, will create an interpretation of all the figures that combine to make the muqarnas types, a spatial composition of interlocking volumes. This focus on composition units (cube, sphere, wall, columns, and arches) will be used as a model to guide this study.

The **third** aspect will analyse the evident proportional order and harmony of each element of the muqarnas units. This will use an orthogonal planning grid and a 1: 2 and 1: 3 proportional system that can be simply generated from the geometric division of the circle, and which is produced from studying the plan and section of the building.

The **fourth** part will concentrate on the identity and structure of the muqarnas with reference to meaning. This will offer a theoretical interpretation of the structuralist approach to shed light on important intellectual aspects related to the meaning and symbolism of the muqarnas. The chapter will include the aesthetics and symbolism as embodied in the surface structure as the transformation of the deep structure which presents meaning. This gives rise to the claims of the study that the muqarnas identity and structure were the result of an evolutionary process. This identity has rules based on culture, continuity, aesthetics, taste and meaning. It encompasses aesthetic values; social and cultural dimensions; symbolism; unity and cosmology. The chapter will include surface structure; with subsections on typology, form, space and ornamentation. The research will continue by examining deep structure, which will cover the following topics: order, hierarchy, wholeness and transparency. Identity will be discussed in the context of the above.

The **fifth** aspect will concentrate on the design of the muqarnas, taking its key characteristics and developing the software to which professionals in the field will be able to refer when designing the muqarnas in the context of Islamic architecture. By utilising state-of-the-art technology, this will lead to a small software program using the 'Generator of Muqarnas' program as a tool in order to produce a muqarnas design creation solution, including the establishment of the required muqarnas design. Practitioners will be able to create images that will continue to nurture the process of transformation and evolution and the aesthetic dimension of Islamic architecture and art. The last chapter **sixth** will conclude with a brief overview of the thesis and the significance of the study.

A number of previous muqarnas software programs have treated their performance into specific design and specific plan. These programs have prioritized it as a supplementary within the overall support of their research study and references. A number of detail investigation of the muqarnas within the broad research objectives, and decodes historical muqarnas in history according to the origin and geographical have been undertaken. In an analysis by Yaghan's (2001-5), he created a software program for creating muqarnas. Further he also offered a short on-line course on muqarnas, following his previous muqarnas work. His work is extremely important for the assessment and contribution of the author and his understanding of many details in architecture elements, such as algorithms, imagination of a third dimension, requirement of corbel support of the basic decorative of muqarnas. This author has studied the projection of muqarnas boundaries into many connected compartments without leaving any gaps in between. This allows the users to create a two-dimensional geometrical pattern that can divide an area clearly defined by certain boundaries. Also it allows a three-dimensional muqarnas form whose visual function is to provide the gradual transition between two levels, two sizes, and two shapes. On the other hand, the muqarnas consists of orderly horizontal layers stacked one on top of the other, connected via their bases and tops and separated by layer joints that are then filled by roof patches which are like stars.

Various other programs have used graph theory for drawing the muqarnas, using algorithms to transform them into specified shapes and forms. Hamsen and Jungblut (2007) provided a reconstruction of Seljuk muqarnas, with the possible combinations of elements in tiers. They have given a two-dimensional plan from which it is possible

to determine directed graphs, however with careful adjustment of some free directions manually, it allows the users to generate a three-dimensional models automatically.

Further it can be used for a basic geometrical forms and descriptive detail in the construction of architectural models from *Bastam in Al-Kashi* architectural models in Muqarnas Visualization in the Numerical Geometry Group (al-Kashi, Centaurus, 193–242). The plane projections of the two different types of elements, cell and intermediate element, are simple geometrical forms. They have divided the muqarnas into six elements as a cell element or intermediate elements or both, and how they can be assembling together and display by software. They are discussed in the numerical geometry group of muqarnas visualisation (Dold-Samplonius, 2003).

Other examples, research by Takahashi (1973 - 2000), has shown the most important images of around 2000 muqarnas, with many details of the functions and materials, and how applicable to their type of muqarnas databases. Also, there are studies providing definitions of the muqarnas, geometrical analysis of them and different technical construction techniques (Castera, 1999), another study depending on muqarnas types (Paccard, 1981).

The muqarnas has become integrated so completely into Islamic art, design, and architecture and it is recognised as such a crucial element within it, that it is timely now to undertake a comprehensive review and bring its aesthetics and technical functions to the attention of a new generation of practitioners.

Accordingly, this thesis intends to redress this deficit and describe the richness of the space and forms to be found in the muqarnas types and to assemble conceptual

models of their construction. Muqarnas compositions are very suitable for contemporary interpretation. They can be designed as ornaments for modern interiors and can be given new functions, such as lamps or display cabinets. It is possible to make a plaster muqarnas coving for an interior. They have a unique beauty quite distinct from traditional two-dimensional geometry.

The importance of the muqarnas in the field of Islamic art and architecture cannot be overstated and this study will highlight its value, so that it can be appreciated by contemporary practitioners, especially if we use the exact geometric rules, proportional system, shaping and aesthetic values and make them accessible via a simple software program. This innovative approach would introduce the aesthetics of the muqarnas to a new audience and it would revivify its significance to Arabic-Islamic art and architecture.

## **1.2. About the research**

The first chapter is focused on the first key aspects of this study; the muqarnas in contemporary art and epigraphic design. The author will start with a review of the research project, identifying the problems or questions that need to be resolved or asked. The potential of this research contribution to the body of knowledge about the muqarnas is mostly based on their effect. The research scope, aims, objectives, methodology and the significance of the research will be detailed in this chapter and illustrated by specific graphs.

## **1.3. Research area**

The research topic has been refined from an initial investigation of the muqarnas as a decorative element, that is, it is a type of structural decorative finishing strip; it is a

corbel used in Islamic architecture and as a decorative motif, an enriched block or horizontal bracket. It is generally found under the cornice and above the bed-mould of Corinthian entablature, and at the same time, it hides the transitional zones between various surfaces (e.g. arches, domes, capitals, windows, ceilings, minarets, mihrabs, minbar, façade and a variety of furniture) in a number of shapes and forms, in some circumstances, resembling stalactites. It has been applied, artistically, to different materials (e.g. stucco, stone, marble, wood, faience and polychrome) in unique geometric arrangements and at regulated distances. The use of the muqarnas reached a very sophisticated level in Andalusian and Ottoman art, such that some of its devices became defining features of medieval Islamic architecture. Over time, a series of causal relationships between Islamic and contemporary art has developed, and it is this relationship that the author wishes to see strengthened, and by integrating the muqarnas into software, he intends to make these motifs and their application more appealing to the contemporary student.

The final aspect of the research area is concerned with refining the research topic from the origin and development of the muqarnas to its integration into software via a computer-generated model, in the hope that the muqarnas will be used more in Islamic architecture.

#### **1.4. Research title**

### **The Muqarnas in Contemporary Art and Epigraphic Design**

Developing technical vision in the design of the Muqarnas

### 1.5. Research scope

The research will explore the aesthetic aspects and the harmonious proportions of the muqarnas in order to discover the fundamental rules of its designs such that they can then be integrated into software to facilitate, enhance and simplify the study of Islamic architectural ornamentation. This study is concerned with the following periods:

A- The periods that are connected with the emergence of the muqarnas:

- Persian art in Iran and Iraq between the third and sixth AH centuries.
- Christian art in Syria in the third and fourth AH centuries.
- Coptic art in Egypt in the fifth and sixth AH centuries.

B- The periods that represent the apogee of the muqarnas:

- |                   |             |
|-------------------|-------------|
| • Seljuk art      | (1038–1307) |
| • Andalusian art  | (1146–1192) |
| • Mamluke art     | (1250–1516) |
| • Ottoman art     | (1517–1919) |
| • Modern art      | (1920–1970) |
| • Post modern art | (1980–1999) |
| • New age art     | (2000–2009) |

The study is concerned with the implementation of the rules that would be used in the designs of muqarnas in computer-generated programs.

### 1.6. Research Question

#### 1.6.1. Aim

The research aim is to undertake a comprehensive study of the muqarnas, which addresses its origin, structure and symbolic meaning. The aim is also to transform the



muqarnas to suit modern use without losing its meaning. The author's aim is to examine how the muqarnas can be developed in line with criteria pertaining to the modern world. Art and architecture practitioners and contemporary viewers will find alternatives ready for use as assisted computerised two-dimension and three-dimension drawings which will help artists and architects in their profession.

### **1.6.2. Objectives**

1. To contribute to an awareness of the significance of the muqarnas in terms of nurturing the cultural identity of its Islamic heritage and transforming it to a modernistic up-to-date view. This will be achieved by exploring the classical muqarnas along with its origins and how it works.
2. To establish conceptual types for the muqarnas as technical terms.
3. To develop the types of muqarnas, by using spreadsheet software.
4. To apply the models of the muqarnas in use, and to compare the outputs with the model (computer blocks) in order to assist contemporary students and designers.

## **1.7. Research method**

The methodology of this research focuses on how the aim and objectives of the research will be fulfilled. The steps of the research methodology are as follows:

### **1.7.1. Literature review**

The literature review is an essential process, it gives a general overview of the subject, and the more the literature is reviewed, the clearer the picture that will be obtained from the relevant topics related to the subject.

### **1.7.2. Investigation**

- A methodology will follow a study of the muqarnas history, which will be concerned with the emergence of the muqarnas and its development.
- A descriptive methodology will follow a study of the design of the muqarnas in Seljuk, Andalusian, Mamluke and Ottoman styles.
- An analytical methodology will follow an analysis of the fundamental designs and types of muqarnas.
- Working from original muqarnas types, the author will develop new types, by using their exact geometric rules, proportional systems, shapes and aesthetic values and will make them accessible via a simple software program.
- Muqarnas types will be developed via computational logic (algorithms, dash operations) and programmatically (a database of the rendering and modelling).
- The confirmed design of the muqarnas program (Generator of Muqarnas) will be produced.

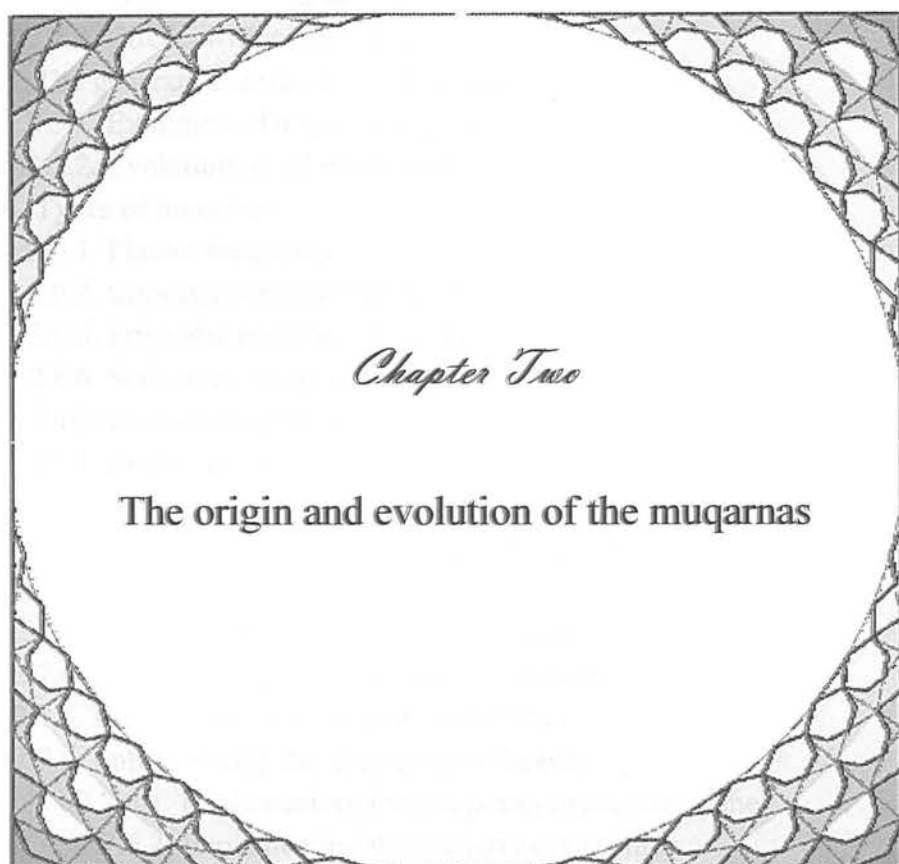
### **1.8. The significance of the research**

This study will highlight the importance of providing a simple software program of the muqarnas, relevant to the field of Islamic architecture, epigraphic design and art, such that it can be appreciated by contemporary practitioners, especially contemporary viewers, who will find alternatives to the model (muqarnas blocks) which they can assess and have ready for use as assisted computerised 2 dimension and 3 dimension drawings. This will help artists and architects in their profession to make the application of muqarnas more appealing to contemporary art and epigraphic design.

In this study, the author will focus on producing a software version for new muqarnas technology which is intended to draw some of the most common shapes of muqarnas.

This software version has the following advantages:

- a- It is easy to use; no great experience of AutoCAD is required. The user just enters a few parameters and lets the software do the rest.
- b- It is an AutoCAD-based application; the author can apply all AutoCAD commands to the Generator of Muqarnas, e.g. COPY, MIRROR, RENDER and so on.



## **Chapter Two: The origin and evolution of the muqarnas**

- 2.1. Introduction
- 2.2. The seed
  - 2.2.1. What is a muqarnas?
  - 2.2.2. Etymology of the muqarnas
- 2.3. The emergence of the muqarnas.
  - 2.3.1. Circles to circles shapes
  - 2.3.2. Circles to squares shapes
- 2.4. Instructional and construction arrangement
  - 2.4.1. Square with circles shape
  - 2.4.2. Circles with square shape
- 2.5. The generative units of the muqarnas.
  - 2.5.1. Evolution of a sphere angle corner
  - 2.5.2. Evolution of spherical triangles
- 2.6. Types of muqarnas
  - 2.6.1. Plainer muqarnas
  - 2.6.2. Concave composite muqarnas
  - 2.6.3. Prismatic composite muqarnas
  - 2.6.4. Stalactites muqarnas
- 2.7. Utilisation of muqarnas
  - 2.7.1. Implementing the muqarnas in arches
    - 2.7.1.1. Implementing the muqarnas in intrados arch
    - 2.7.1.2. Implementing the muqarnas in extrados arch
  - 2.7.2. Implementing the muqarnas in capitals
  - 2.7.3. Implementing the muqarnas in domes
  - 2.7.4. Implementing the muqarnas in minarets
  - 2.7.5. Implemented the muqarnas in Portals
  - 2.7.6. Implementing the muqarnas in facades
    - 2.7.6.1. Implementing the muqarnas in recesses panel
    - 2.7.6.2. Implementing the muqarnas in cornice
    - 2.7.6.3. Implementing the muqarnas in cantilever
  - 2.7.7. Implementing the muqarnas in mihrabs
  - 2.7.8. Implementing the muqarnas in minbars
  - 2.7.9. Implementing the muqarnas in furniture
- 2.8 – Materials of implementation of muqarnas
  - 2.8.1. Gypsum (Plaster)
  - 2.8.2. Marble
  - 2.8.3. Stone
  - 2.8.4. Wood
  - 2.8.5. Metal
- 2.9. Conclusion of Chapter Two

## 2.1 Introduction

The second chapter focuses on the first key aspects of this study: the muqarnas in contemporary art and epigraphic design. The author will begin with a review of the terms used to describe the muqarnas and, along with a discussion of the etymology of the word, he presents a new comprehensive definition of the muqarnas, including its development, general overview, origins, formality and chronology. Then he conducts a historical review, in which he discusses where the muqarnas comes from, which countries, areas, cities and buildings, and at the same time he explores the culture of the organic rules of the muqarnas. The author then begins a review of the evolution of the muqarnas, where he will focus on the aesthetic value, on the architectural aggregation and the formal principles of artistic composition applied in the ornamental patterns of Islamic art, with reference to both the physical forms and the conceptual vocabulary of meaning and the symbolism used in architecture.

Another aspect of this chapter, the spatial, will create an interpretation of all the figures that combine to make the muqarnas types, a spatial composition of interlocking volumes. This focuses on compositional units (cube, sphere, wall, columns, and arches), and uses this model to guide this study. In fact, the muqarnas is part of several studies in engineering and archaeological fields. However, it has always been considered as part of a general study and not as the substantial theme of an exclusive research. Most of these studies have dealt with the descriptive aspects of the muqarnas and not with its formal analysis or aesthetic dimensions. Moreover, some of the studies have dealt with the materials used in its construction. In other words, these studies did not include comprehensive research into the muqarnas and its aesthetic values.

## 2.2. The seed

Certain Islamic architectural features have become fixed and eternal. In this modern world, they help us find our architectural roots and to remain true to our identity. It is the historical roots of the muqarnas, which is an important element in Islamic architecture, and its use for architectonic and decorative purposes that are the focus of this chapter. The muqarnas is implemented in the design of arches, column capitals, windows, ceilings, domes, minarets, and concave niches known as mihrabs in a variety of shapes and forms with unique geometric arrangements. A study of the muqarnas from different periods and in different styles, such as Seljuk, Andalusian, Mamluke and Ottoman architecture, will therefore provide us with an understanding of the fundamental aesthetic aspects of its design.

### 2.2.1. What is a muqarnas?

Muqarnas is the Arabic word that describes a traditional element unique to Islamic architecture and a type of structural decorative finishing strip. It is a corbel used in Arabic-Islamic architecture and as a decorative motif, an enriched block or horizontal bracket. It is generally found under the cornice and above the bed-mould of Corinthian entablature, and at the same time, it hides the transitional zones between various surfaces (e.g. arches, domes, capitals, windows, ceilings, minarets, mihrabs, minbars, façades and a variety of furniture) and appears in a number of shapes and forms and in some circumstances, it resembles stalactites. It has been applied, artistically, to different materials (e.g. stucco, stone, marble, wood, faience and polychrome) in unique geometric arrangements and at regulated distances.

The muqarnas can be described as a sort of stalactite that is required in order to support a dome in the form of niches.

They are repeated, one after the other, in the same way as the cells of a honeycomb. They can also take the form of crystals repeated, clustered together, radiating from a central axis (Burckhard, 1976, p.70).

A muqarnas has many functions in Islamic architecture; it articulates a carved space, dissolves surfaces contrasting space, creates a frame for related but discrete motifs, and acts as a decorative motif consisting of numerous niches and niche fragments. It is used primarily as internal cladding for curved architectural elements with an elaborate domical construction and is the gradual transition between two levels, two sizes and two shapes, for example, in domes and in the transitional zones between domes and their supports, and also in concave niches, tops of window openings, on capitals instead of tambours, and ledges. Small niche-like components are combined with each other in successive layers to enclose a space and to produce surfaces rich in three-dimensional geometric compositions. Muqarnas in one form or another are essential elements of all Islamic architecture (Hoag, 1977), all over the central and eastern parts of the Muslim world, and they are applied to an ornamental frame of projecting niches (El-Basha, 1965).

Another view of the muqarnas provided value wherever it was used, the nature and depth of the volume being left to the discretion of the maker;

It could be used both as an architectonic form, because of its relationship to vaults, and as an applied ornament, because its depth could be controlled (Harmsen, 2003, p.35).

It is an Islamic innovation and a traditional Islamic architectural style of decoration, which described at All-Experts Encyclopaedia "it usually consists of three-



dimensional wedge forms that are combined into intricate designs to create honeycomb patterns on walls, vaults, and domes" (Allexperts Encyclopaedia , 2006), and is used as a means of passing from a vertical plane to a plane with a different orientation.

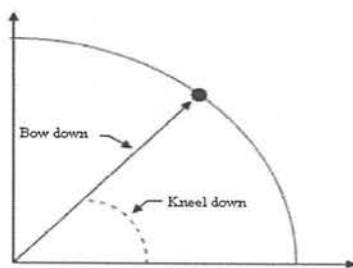
The muqarnas reveals a perfect understanding of the principle of subdivision and integration and seems to have sprung from the passion of artists and architects to express the interrelationship of these principles, by either differentiating an elementary spatial unit – the niche – into a multiplicity of related smaller forms, or by bridging, step by step, the subdivision between individual smaller units and thus reconverting multiplicity into unity. Symbolically speaking, this geometrical process of differentiation and integration may be seen as an image of the unfolding and retraction of the created world as often evoked by the verses (*Ay'ats*) of the *Qur'an*. In other words, arguably, the muqarnas can be thought of equally as both art and skill. The artwork is at the same time mathematically precise, aesthetically pleasing, and symbolic. However, for many Muslims there is no distinction; all forms of art, the natural world, mathematics and skill are all creations of God and therefore, they are reflections of the same thing (God's will expressed through His Creation).

### 2.2.2. Etymology of the muqarnas

The word 'muqarnas' comes from the Arabic word '*Qarnasi*', where *qarnasi*-ceiling or *qarnasi*-home, refer to decorating the ceiling and home by ornamentation with a balanced category (Haroon, 1960). In 1183 AD, the Andalusian traveler *Ibn Jubayr*<sup>i</sup>, used the word *qarnasi*, when he described what he saw in Islamic architecture and art

works, in North Africa and Middle East. The word *qarnasi* means intricate work or carving work as his describe (Bloom, 1988).

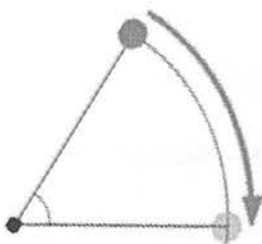
The word probably also came from the Arabic word '*Mu'qarfas*', which means to undertake squats, for a total body workout, that is, to stand up and then to undertake an exercise ('squats') that involves bending your knees and making as if you are about to sit down repeatedly, such that it works the thighs and bottom, toning the muscles in these parts of the body and thus, there is a similarity between the muqarnas vault (Mar'awq, 1974), which does resemble the body movement of squatting, especially in worship during prayers to God (Fig. 2.1).



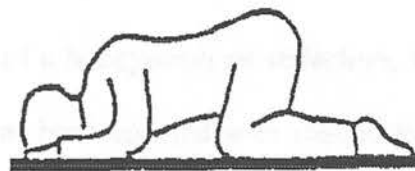
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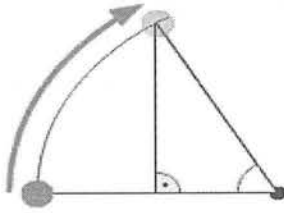
*Muqarfas* (sit-squat)



Band the body as sign in



Kneeling



Band the body as sign up



Adoration

Fig. 2.1. Squats, for a total body workout

The definitions found in the oldest Arabic dictionaries connect the word with the concepts of fragmentation and unsupported projection, both of which indeed characterise the motif. The probable Arabization of the old word was derived from the Greek *korvns* (Latin *coronis*, Fr. *corniche*, Eng. *cornice*).

Muqarnas is the singular substantive and *muqarnasat* is the plural substantive (Ghalib, 1988), sometimes written muquarnas; plural muqarnasat, but in this research, the author will use muqarnas.

It has often been compared with the form of a honeycomb or stalactites, which their applications are on ceiling and dome. It has been equated with stalactites, generally used in western languages to designate the muqarnas, where it is easy to see them as stalactites (Castera, 1999.). In the perception of some scientists and researchers, whose stalactites (stala-c-tites and stala-g-mites)<sup>ii</sup> are formed by water dripping inside caves, resembling the origin of the muqarnas shapes<sup>i</sup> The expression of this natural beauty has come into architecture in the form of the muqarnas, whose motifs give the same impression as natural stalactites, which hang like icicles from the ceiling (Britannica Encyclopaedia, 1980) or en masse, they hang from a cave roof,

particularly limestone caves (Americana Encyclopaedia, 2000) or like mineralised water solutions forming at the bottom of stalactites, whereas a stalagmite appears like an inverted stalactite and arises from the floor of a cavern (Fig. 2.2).

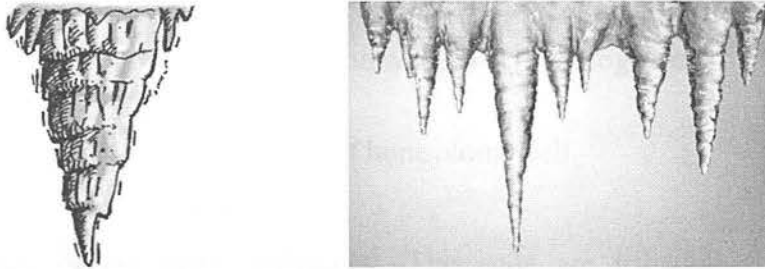


Fig. 2.2. Stalactites, which hang like icicles from the ceiling

Westerners' understanding of the muqarnas and their equating it to stalactite vault shapes may be a symbolic representation of the muqarnas idea, which does not necessarily have a similarity in shape to that of a vault. The vaults in an arched roof of a designed ceiling are known as barrel or tunnel vaults, groin or cross vaults, domical vaults and rib vaults (Osborne, 1997).

Europeans compared the form to a honeycomb, and thus called it a 'honeycomb vault' or "honeycomb work" (Hoag, 1977, p. 405). It is likely that the honeybee constructs the honeycomb based on instinct, and the closed ends of the honeycomb cells are also an example of geometric efficiency, albeit three-dimensional. A group of muqarnas is composed of a honeycomb-cell, which consists of three rhombuses used by the honeycomb. Thus the Arabs introduced a stylised form of a natural element to their interior Islamic architectural ornamentation. This is repeated and multiplied on a smaller scale. The shape of the cells is such that two opposing honeycomb layers interlock each honeycomb-cell into each other, with each facet of the closed ends being shared by opposing cells (Fig. 2.3).

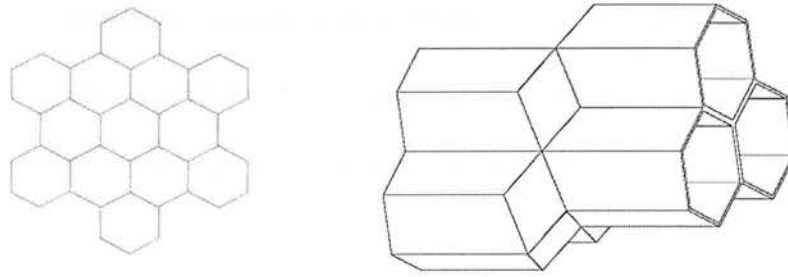


Fig. 2.3. Opposing layers of honeycomb cells fit together.

According to Thompson (1942), on a form of honeycomb cell,

An example of geometric efficiency, The ends are trihedral (i.e., composed of three planes) pyramidal in shape, with the dihedral angles of all adjacent surfaces measuring  $120^\circ$ , the angle that minimises the surface area for a given volume. (The angle formed by the edges at the pyramidal apex is approximately  $109^\circ 28' 16'' (= 180^\circ - \arccos(1/3))$  (Thompson, 1942, [Honeycomb], 2009). (Fig. 2.4).

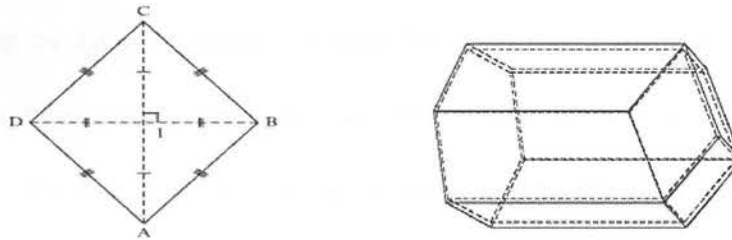


Fig.2.4. The three-dimensional geometry of a honeycomb cell.

Another expression of the muqarnas element, the single muqarnas resembles a little *mihrab* (small concave niche), varies in size but is usually ornately decorated. At the same time, "they conceal the transitional zones between various surfaces, especially in a building" (El-Basha, 1965, p.34), that is passing from a vertical plane (columns or walls) to a horizontal plane with a different direction. Initially, they were intermediate elements or corbels, appearing gradually until they reached the desired form. That builders used consisted of a set of molding of little *mihrahs* or small concave niches or of longitudinal (front-to-back or top-to-bottom) parts, bracketed one above the other, or they consisted latitudinal by hanging or stabilising some of the layers or

constructive lines side-to-side, in which small niche-like components were combined with each other in successive layers, to enclose a space and to produce surfaces rich in three-dimensional (3D) geometric compositions (Sameh, 1970).

Grabar (1996), pointed out that the Arabs hate plain surfaces unlike the Greeks, because they hide the hard edges of corners and the shapes of the right angle by creating intangible transition zones to allow, visually, flat smooth surfaces to occur, such that they set up small concave niches of drooping hanging stalactites' from the ceiling, which seem like a honeycomb.

It is important to keep in mind a subtle but significant distinction between the muqarnas as a decorative system and the forms which are applied in domes, vaults, cornices, and capitals. The power of architecture lies in the extent of uniformity of construction and aesthetic decoration and the importance of the work as a whole over the importance of the individual units and their aesthetic composition. In addition, the muqarnas is a three-dimensional decoration in Islamic architecture. From time immemorial, the beauty of the muqarnas was referred to by travellers and writers, who described their carvings as covering over what had been carved as molding.

Travel writers used the term muqarnas frequently, in 1183 AD, the Andalusian traveler *Ibn Jubayr*, in Egypt, Maghreb (Morocco) and Hejaz (Makkah), when he described what he saw in Islamic architecture, such as minber, dome, mihrab and art works. (Nasser, 1924). Particularly interesting is his description of the *al-Masjid al-Haram* in Makkah, in Saudi Arabia. Especially important is his description of the *Bab*

*Ibrahim* annex to the *al-Masjid al-Haram* which was built by *Muhammad Ibn Musa al-Muatadir's* governor in Makkah, during the early part of the tenth century, he wrote:

Over the portal is a large dome (*qubba*), remarkable because it is almost as high as the adjacent minaret (*sawma'a*). Its interior is covered with marvellous plaster work and *qarnas* carvings which defy description; the exterior is also made of carved plaster, resembling interlaced column drums (Bloom, 1988, p.27).

An Arabic poet also described muqarnas, in the ninth century,

The door is not *al-Estrechal* to be long and be hang down with door *Mja-sass* embellishment, and *Gha-w-Shi* the crown decking on the head of the muqarnas<sup>iii</sup> (Abdulhameed, 1924).

The muqarnas were also described in one of the poems '*Al-Sharif Al-Boisseri*' (1211-1296 AD), when it gives a command for the construction of the School *Mansouriyye* in Cairo in 1284 AD,

a fantastic honeybee of hanging stalactites' which seem the work of bees rather than of man, and made it as elasticity of the rocks such as honeycomb<sup>iv</sup> (El-Bash, 1988, p.123).

Dalu, writes in a very motivating and useful essay entitled '*Surface, Pattern and Light*',

That many devices typical of Islamic architectural decoration, for example, muqarnas (a honeycomb decoration that can reflect and refract light), are explained by a desire to dissolve the barriers between those elements of the buildings that are structural (load-bearing) and those that are ornamental (non-load-bearing) (Dalu, 1991, p.144).

In this context, the muqarnas are connected to the sky, especially when light plays on them during daylight hours or in the movement of the shadows, and of the movement of the universe around it. Some purists may feel that there is something overripe about

muqarnas, something decadent, about its rich and ornate decoration, its riot of red and blue and gold tile work and painted stucco.

### 2.3. The emergence of the muqarnas

The first muqarnas were developed as a simple construction in corner squinches or pendentives in domed rooms and buildings were designed to support arch or dome; there was no decoration in the beginning. Some archaeologists believe that the origins of the muqarnas are related to the fact that some of the muqarnas molding is located in one corner of the polygonal projection which is based on the transitional zone to the dome. Domes on squinches are only known in Parthian and Sassanian architecture and, according the Creswell, it is a Persian invention. (Creswell, 1940) (Fig. 2.5).

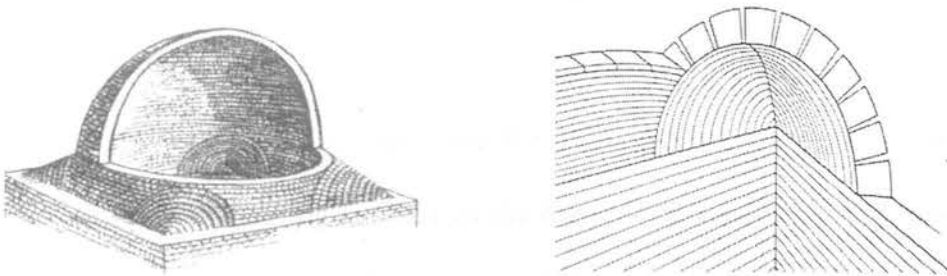


Fig. 2.5. The constructional technique of the dome

The idea of the muqarnas is related to the emergence of the dome (Al-Any, 1983) as a transitional zone between various surfaces, and the most probable idea with reference to its development concerns the corner area and the transition from the wall structure to the domed ceiling. This transition is actually achieved in two principal ways, both of which depend, in a way, on the construction of four arches, and involve spherical triangles (Shafie, 1954).



Therefore, the transition zone from the wall to the dome involved spherical triangles in order to join the two inner forms of the construction. Each façade of the building has two tiers of three-arched niches, hollowed out of the principal mass. The portals in the centre of each side are a magnification of these niches. They are, in their turn, each filled by miniatures of themselves, and with the repetition of this small spherical inclusion at each of the corners, a complete unity was derived; this was the earliest version of the muqarnas (Okasha, 1985).

These mouldings of the muqarnas evolved in Islamic architecture. They usually consist of three-dimensional wedge forms that are combined into intricate designs to create honeycomb patterns on walls, vaults, and domes. A round dome can be difficult to place over a square or circular base, resulting in four gaps between the area of the square and the area of the circle in each corner which holds up the four corners of the circumscribed circle. The constructional technique was originally built to cover a square space, by bridging the corners until the edges met in the middle, 'quadripartite vaults' made without centring the base of the dome. This could be easily achieved by further slight corbelling across the corners of the polygon (Lewcock, 1991, p. 140) (Fig. 2.6).

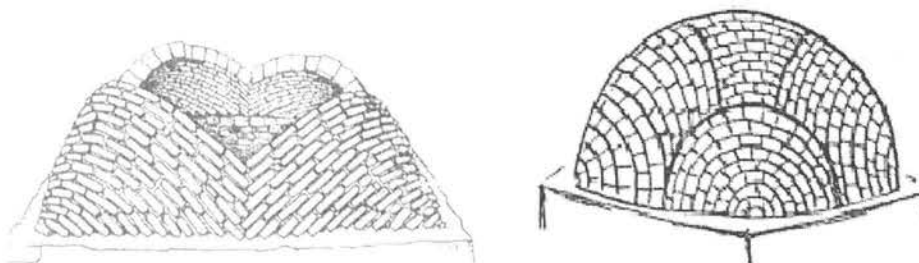
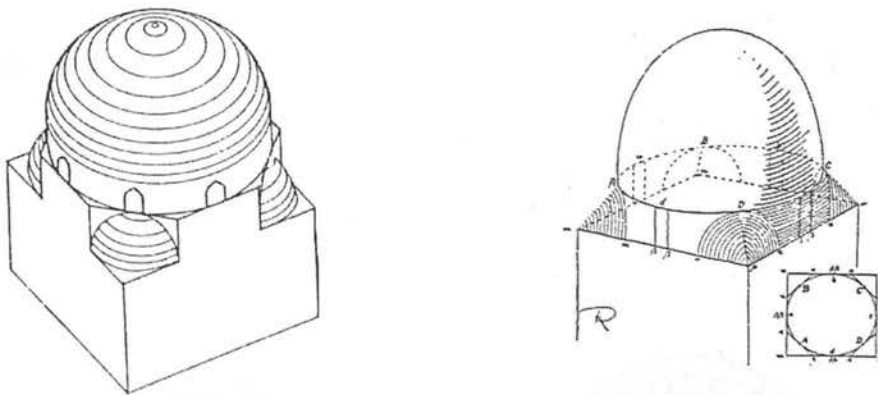


Fig. 2.6. Quadripartite roof showing how Bricks are laid.

The technique can be traced back to the seventh century BC in the Palace of *Khorsabad* where the arches are formed with flat square bricks. (Creswell, 1940).

The constructional technique of the dome in Fig. 2.6 was originally built as a covering for a square space by bridging the corners until the edges met in the middle.

Pre-Islamic domes in Iran are all supported on squinches. This device transforms the square base into an octagon, throwing arches across the corners of the square, thus providing a transitional zone on which it is easy to set the circular base of the dome (Fig. 2.5), as the author mentioned before (Fig. 2.7).



2.7. Dome on squinch

The exterior side of half of each of the square's side transfers the square perimeter to an octagonal perimeter, and then the four remaining corners are empty, requiring four triangular quarter curves to lean towards the void of the spherical space under the dome. The length of each of them must be equal to the side of the octagonal shape that runs at a tangent inside the circle 'dome support'. This contradiction and difference between the four walls of the square shape and dome base of the circular space, has encouraged architects and artists to visualise and construct a unit which handles this imbalance. Islamic architects developed a number of ingenious and

beautiful solutions (Okasha, 1985), this was the origin of the muqarnas, which moves easily between curves and arched surfaces.

Muqarnas is a corbel used in a decorative motif, and at the same time, it hides the transitional zones between various surfaces in a number of shapes, such as a sphere angle corner shapes and spherical triangles shapes in domed rooms. It has been applied artistically, to different construction (e.g. circular, square or octagonal), in unique geometric arrangements and at regulated distances, as follows:

### 2.3.1. Circle to circle shapes

In the case of the base of the dome on a circular projection, by constructing a circular geometric shape on a circular geometric shape, a gently curved dome on a cylindrical drum projection with a circular shape is produced (Fig. 2.8).

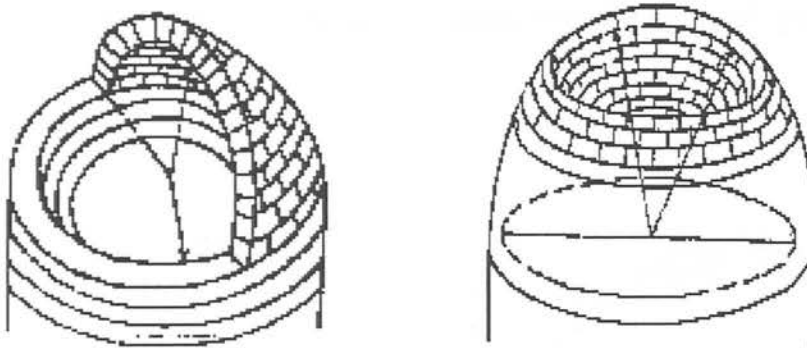


Fig. 2.8. Dome on cylindrical projection. A circular on circular shape

This device transforms the circular base onto a circular surface in a domed room, thus providing a transitional zone upon which it is easy to set the circular base of the dome (Shafie, 1970, p.115).

One of the oldest examples of a dome is to be found on the south-eastern Greek mainland, built during the period of Mycenaean art in 1600 BC. It is an impressive structure, and was built of concentric layers of precisely cut stone block, with conical stone chambers, known as 'beehive tombs'.

Its discoverers thought it far too ambitious for a tomb and gave it the misleading name - The Treasury of Atreus - (Janson, 1962, p. 88). (Fig. 2.9).

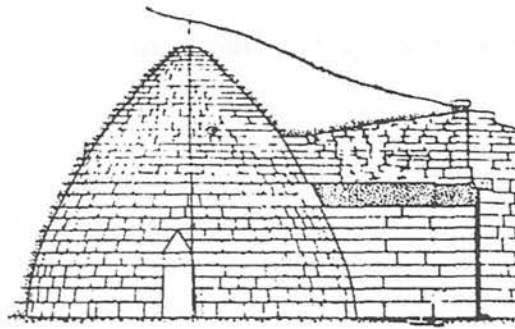


Fig. 2.9. The Treasury of Atreus.

The most fascinating example of a dome before Islam was in Roman architecture, in the Pantheon in Rome, which was built in 27–25 BC, and is the oldest important building in the world with its original roof intact (Wolfgang, 1958. pp 23-53) (Fig. 2.10).

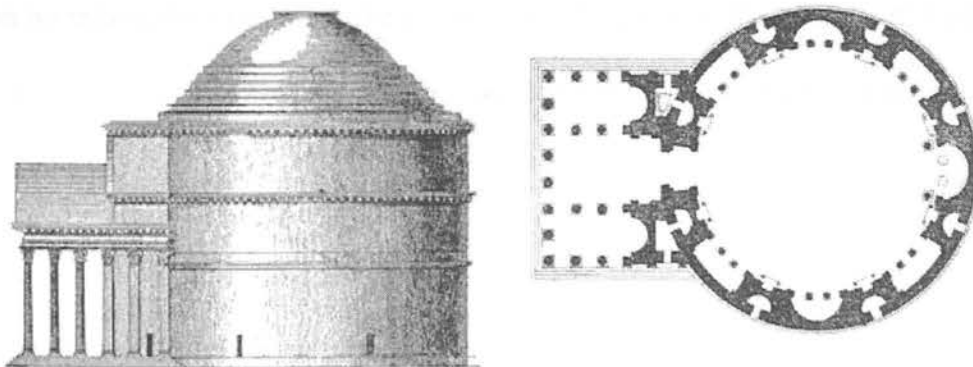


Fig. 2.10. Plan of the Pantheon, Rome

### 2.3.2. Circular to square shapes

In engineering terms, a circular dome can be difficult to place over a square base, which holds up the four corner squinches of the circumscribed circle<sup>v</sup>. Each corner is in the form of a triangle which takes up half the area of the two adjoining side walls and the third is the curve of the interior circle. This is complicated as a result of the circular dome base connecting to the square shape on four points. While the circular dome base rests on the square, this results in leftover space in the four corners that the dome will not cover (Fig. 2.11).

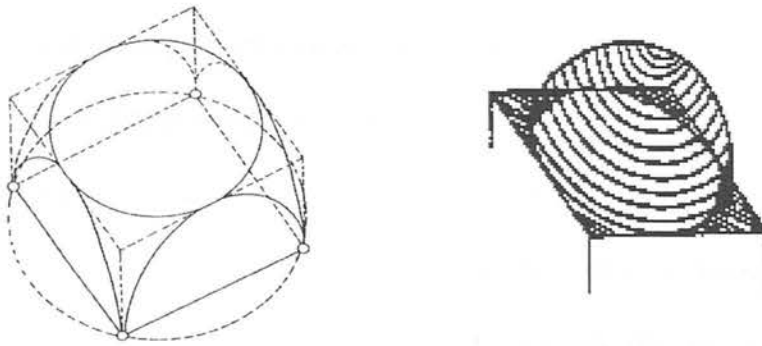


Fig. 2.11. Circular dome rest on square

The difficulty of this contradiction and the inconsonance between the top four walls that form the square, the octagon shape and the circle shape of the dome base has encouraged architects to resolve that difference and inconsonance, allowing easy vision by taking the eye across the constructional curves or flat smooth surfaces. The author will discuss two ways in which architects resolve this situation in the following paragraphs.

## 2.4 Instructional and constructional arrangement

Islamic architects developed a number of structures enabling them to form a ceiling, to construct void pillars and an inner vault surface, providing an aesthetic solution to

the problem of how to join the two surfaces. The simplest one was to use a corner of a square to circle or circle to square, by squinches and by pendentive shapes to support the interior circular dome shape, as follows:

#### 2.4.1 Square with circle shapes

The relationship between the square and the circle is very strong. The squinch method is the architectural term for an arch built diagonally across the corner of a square building to support an octagonal spire or circular dome, and is used to join an exterior square shape to an interior dome. The dome takes the form of a sphere which is established on a circle, square or an octagon. The position of the dome set on a square shape projection is established on a circle, square or an octagon, and this regular systematic geometry results in four gaps between the areas of the square, to the area of the circle in each corner. Again, this relationship between the dome and the square is realised through the use of squinches which connect the square to a circular position. They are set on a square projection, and then the four remaining corners are empty, requiring four triangular quarter curves leaning towards the void spherical space under the dome. The length of each of them is required to be equal to the side of the octagonal shape, which runs at a tangent inside the circle dome support (Fig. 2.12).

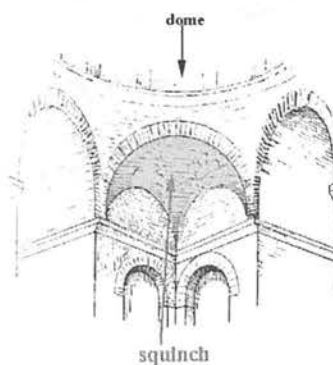


Fig. 2.12. Structure of Squinch

A squinch in architecture is a construction used for filling in the upper angles of a square room so as to form a proper base to receive an octagonal or spherical dome (Aliparsa, [squinch] 2007). Another view is "an arch or a system of concentrically wider and gradually projecting arches, placed at the corners of a square base acts as the transition to a circular dome placed on the base (Stones and Steyaert, 1987), and also, It involves a half-cone level applied to the horizontal ribbed angle corner of the square (Shafie, 1970, p.115).

The style of the squinches is formed by "masonry built out from the angle in corbelled courses, by filling the corner with a vise placed diagonally, or by building an arch or a number of corbelled arches diagonally across the corner. In Islamic architecture, especially in Persia, where it may have been invented, the squinch took the form of a succession of corbelled stalactites (Aliparsa, [squinch] 2007). The transition zone from the wall to the circumscribed circle involved a squinch in order to join the two inner forms in the construction, each façade of the building having two tiers of three-arched niches hollowed out of the principal mass. It is similar to a half-moulding concave cone (Shafie, 1970) (Fig. 2.13).

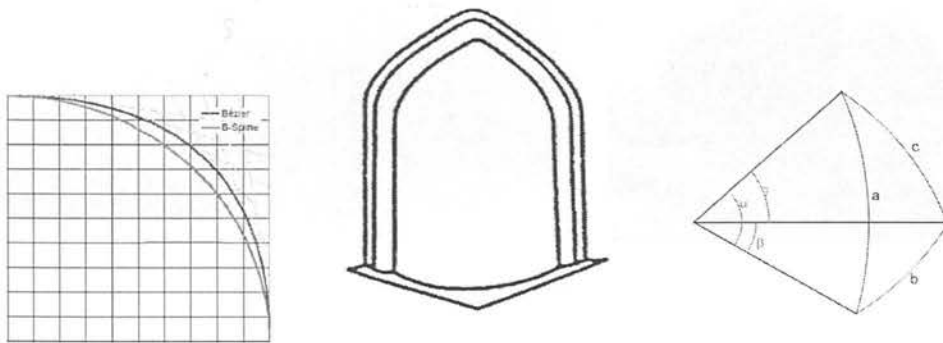


Fig. 2.13. Draw squinch two and three damnation.

This contradiction and difference between the square shape of the four walls and the circular dome base encouraged architects and artists to visualise and construct a unit which handled this imbalance, and which moved easily between curves and arched

surfaces. These recesses covered with a hemispherical vault existed before Islamic art and there are different views on the emergence of the squinch, which was important to innovation and evolution. There is reason to believe that the dome on squinches is the only one known to Sassanian architects (Creswell, 1940), the consensus is that it is of Persian origin (Fikry, 1936). Rivora thinks it is likely that the Romans were the first to think of using squinches and then their use spread east to Persia (Rivora, 1938). However, Rosintal thinks the credit for the squinch goes back to the Assyrians (Rosintal, 1928). Others think that Armenia or Mesopotamia is a more likely origin. Shafie argues that the oldest models appear in Sassanian architecture (Shafie, 1970). The models in the dome were found in the palace of Firouzabad<sup>vi</sup> (Fig. 2.14), "a large building popularly known as the fire-temple of the third century in the Palace of Shapur I AD 242–272" (Janson, 1962, p. 81). Firouzabad is one of the great cities of ancient Mesopotamia in Iraq, and is also known in Arabic as *Madain*, or *Al-Mada'in*.

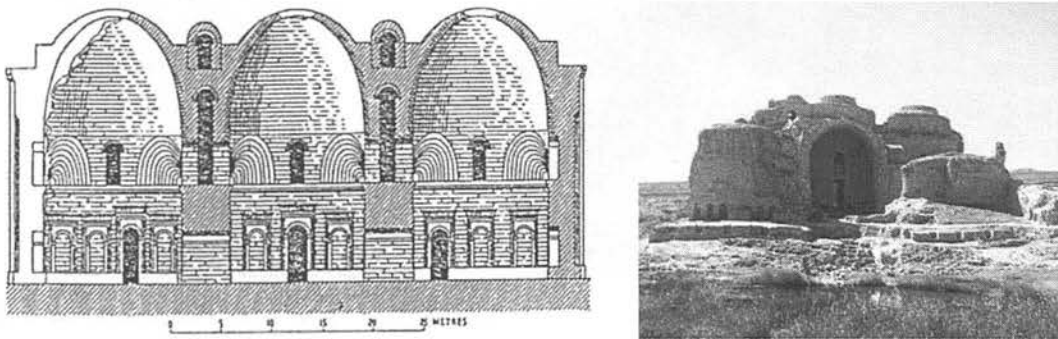


Fig. 2.14. Firuzabad.

Another example is in the *Behram* Palace of 'Bahram V' in Srvstan, in the cypress-garden, from the fifth century AD (420–38) (Creswell, 1940). There is also an example in the *Shirin* Palace, AD 591–628, and similar examples of the squinch were found in Byzantine architecture which came after Sassanian architecture (Shafie, 1970). Then the form emerged in the West and this provided an opportunity to North



Africa, become familiar with this moulding corner from Muslim architecture, and from it emerged new and distinctive identities such as in Egypt.

The oldest example of this arch moulding corner comes from the early Abbasid period (Shafie, 1970, p.142). Moulding corners were used in Sassanian architecture and the oldest Islamic models appeared in the *Ukhaydir* Palace, built in the Abbasid period, AD 777 (Al-Any, 1983, p. 128). In the south-west of the city of *Karbala* in Iraq, in a prayer hall of the mosque, the two courtyard arcades were covered by a tunnel vault decorated with recessed brick work, fluted squinches and a recessed triangle. It is possible to go from the square base of the walls to the round foundation of a dome by passing through an octagonal drum, using squinches in the transition between the square and this octagon (Philon, 1991, p. 251) (Fig. 2.15).



Fig. 2.15. Ukhaydir Palace, in Iraq

Another example of a half dome with a full circle was found in Samarra in the *Jausaq al-Khaqani* Palace from the time of *Al-Mua-Tasim*, in AD 836 (Creswell, 1940, p.331). In what is considered to be the oldest example of Islamic architecture, the squinches in the *Bab al-Amma*, in the *Jausaq al-Khaqani* Palace adopted an Arab Muslim style, which is a covering empty space by small squinches (half semi-dome shapes) (Shafie, 1970, p. 413). Fikry argued that the oldest example of Islamic

muqarnas appeared in the domes of the *Qasr Kharana* in Jordan, AD 614–710, in the west corner room (Fikry, 1936).

A further example of the development of the muqarnas moulding in the squinches can be found in *Ukhaydir* Palace, in which the architect used the muqarnas in corner squinches in domed rooms, and "in the transitions between the double column layouts, based on a crown of the arch" (Al-Any, 1983, p.128). The earliest existing example "in several buildings is the tomb of *Qubbat as-Sulaybiyya* in Samarra, which was constructed during the Abbasid period, AD 892, at the time of *Al-Mostansser Bi-Allah*" (Philon, 1991, p. 250).

A excellent example shown in Fig. 2.16 of the muqarnas in the dome of *Imam Dur*, in Samarra from the *Uqaylid* period AD 1085, used the muqarnas in the corner of the dome squinches, and divided it into three transition zones, each layer having a different span to the next, by complex geometric rules, until the top of the dome is reached. The author will explain this point in the evolution of the muqarnas.

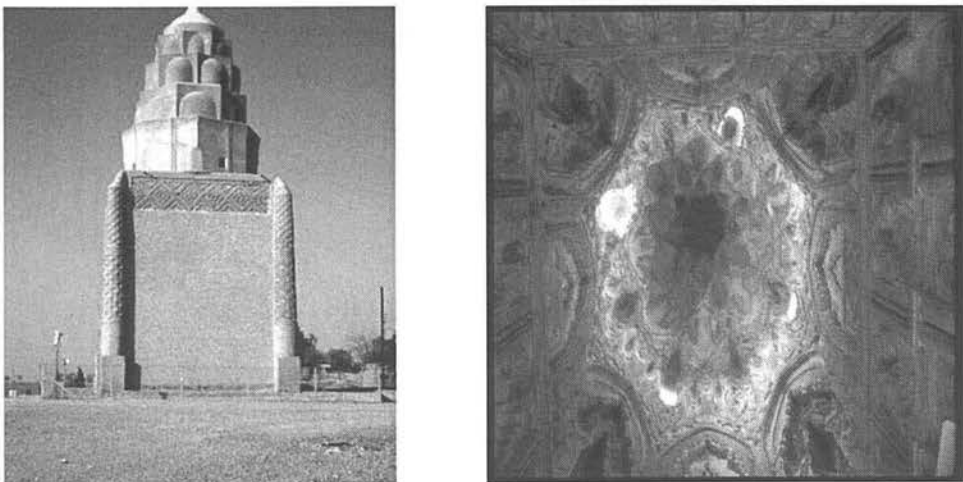


Fig 2.16. Dome of *Imam Dur* in Samarra

### 2.4.2 - Circle with square shape

The relationship between the circle and the square is very strong. The pendentive method of the architectural term for a curved, triangular feature whose purpose is to enable a circular dome to be supported above a square or a polygonal drum (Osborne, 1978), is used in an exterior circle construction to an interior square.

A pendentive is a constructive device permitting the placing of a circular dome over a square room or an elliptical dome over a rectangular room (Heinle & Schlaich 1996, pp. 30–32)

It is a spherical triangle which acts as a transition between a circular shape to a square shape base on which the dome is set.

The pendentive, which is triangular, segments a sphere, and tapers to points at the bottom and spreads at the top to establish the continuous circular or elliptical base needed for the dome. In masonry, the pendentive thus receives the weight of the dome, concentrating it at the four corners where it can be received by the piers beneath. Piers in relation to pendentives' development, the method of corbelling or the use of the squinch in the corners of a room were all employed. The transition zone from the wall to the circumscribed-circle involved pendentives in order to join the two inner forms in the construction, each facade of the building has two tiers of three arched niches hollowed out of the principal mass (Heinle & Schlaich 1996, pp. 30–32) (Fig. 2.17).

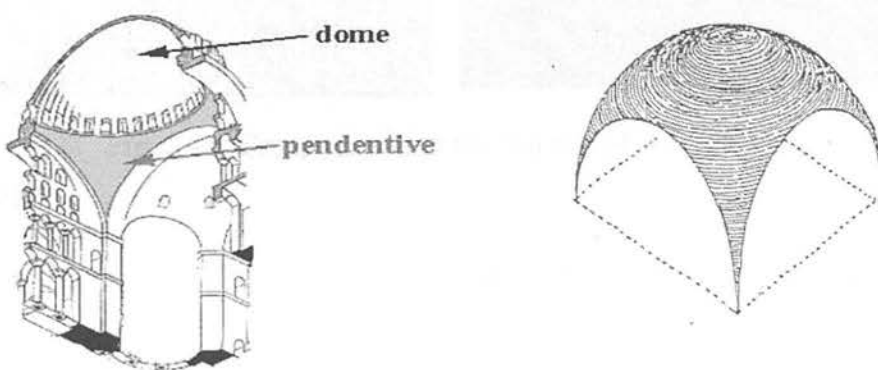


Fig. 2.17. Structure of the pendentive

The first pendentives were made "by the Egyptians" (Okasha, 1985, p.24). Some researchers argue that it is likely that the pendentive was used by "the Arabs in the Syria region *Sham-een* in the fourth century AD" (Shafie, 1970, p.139), but Lamie

considers it more probable that the pendentive can be traced to the Romans, "as it is seen in particular in the Middle East in the Arab region which had been subject to the rule of the Romans and Byzantines, when they extended the Roman Empire into Syria in 132 BC" (Lamie, 1984, p. 128). This is confirmed by Shafie, who traced the oldest model to the late Roman era and the early Christians in the Syria region (Shafie, 1970, p.117).

Pendentives were commonly used in Renaissance and baroque churches, with a drum often inserted between the dome and pendentives, following the building form as it was practised in the Byzantine era in *Ayah Sophia*, Constantinople [Istanbul] AD 532 (Heinle & Schlaich 1996, pp. 30–32).

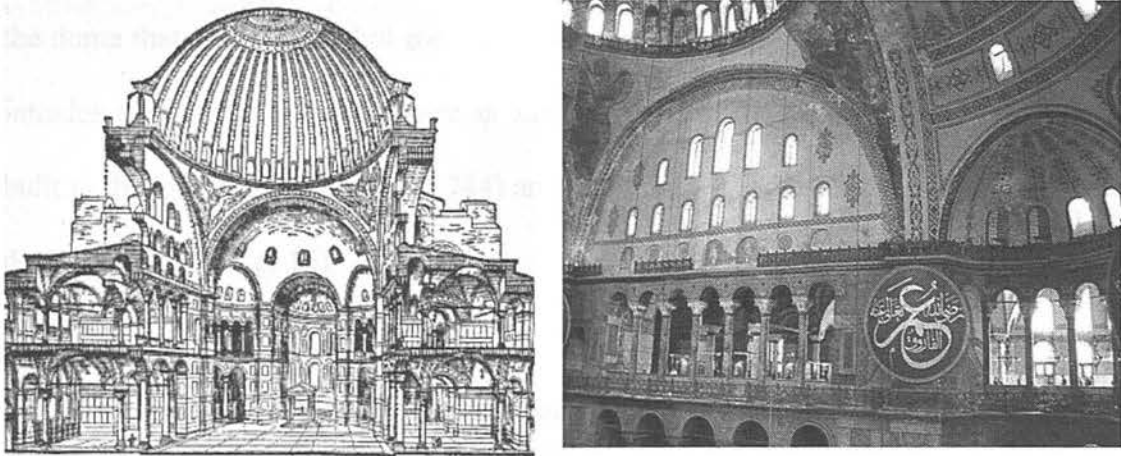


Fig. 2.18. Cross section of the interior of *Ayah Sophia*

Therefore, the technique of ‘softening’ a corner and the pendentive spherical triangles necessary to make the central dome and dome support distinguished Byzantine architecture in terms of the interrelationship of the whole composition. In fact, the construction was organically linked to wholeness with unity as a key principle (Mahmoud, 1987). The example of the baths of the *Ayah Sophia*, illustrated in Fig. 2.18, show how the stalactites of the spherical triangles come from the bottom surface

of the dome to the vault of the central octagon (The author has visited this place, in August, 1999).

Muslim civilisation prevailed with the emergence of Islam. After the expansion of the Islamic region in the 8<sup>th</sup> century, architecture changed to reflect the older concepts and formations of spherical triangles that had matured since the first century of the Prophet Hegira during the rule of the Umayyad, and included several architectural monuments for patrons in Syria and Iraq (Mahmud, 1987). The oldest example of the use of such spherical triangles appeared in the Jordan desert at the *Qusayr Amra* palace and bath, which were built in the Umayyad period AD 712–15, and included three parallel vaults roofing the main chamber, carried on broad pointed arches, and in the dome that covered the hot room is a semicircular dome of spherical triangles and intrados from inner to outer. There also exists dome in the *Mshatta* Palace in Jordan, built in the Umayyad period (AD 744) and the *Tobah* Palace, built at almost the same date (Shafie, 1970, p. 15).

It is worth mentioning that the phenomenon of the spherical triangle, which had begun to be used in the early Islamic era, as was mentioned earlier, continued to be used only a little in Islamic architecture. The reason for this was the spread of the innovation of the muqarnas concave niche (quad-dome) for corner use. This is what the author will outline in the evolution of the muqarnas in the following paragraph (in terms of the generative units of the muqarnas). Another important reason was consideration of the lifetime of buildings with regard to the effects of factors like earthquakes and the other phenomena. Shafie emphasises that the muqarnas element in the transition zones of the pre-Islamic domes in the Middle East withstood

earthquakes and weak walls, and it is a fact that in the history of architecture, in terms of the integrity of the lower part of a construction, the use of the muqarnas can overcome any 'weakness' in a wall, as has been demonstrated following the reconstruction of a muqarnas vault (Shafie, 1970, p. 77).

## **2.5. The generative units of the muqarnas**

The muqarnas is a feature that evolved in various formats and which used characteristic methods; it has been developed and improved through use. Then in the Middle East, Muslim architects drafted a variety of new and innovative designs referring to the distinguished and decorative geometrical units as three-dimensional ornamentation which had been formulated through the centuries, reflecting the features of the Islamic architectural style.

The multi-division of the muqarnas is created from two units: the squinch (sphere angle corner) and the pendentive (spherical triangles) in domed rooms, which support the hemispherical dome in the form of niches which are split up into smaller units, and within these small units, derived from the big unit, the same form of the large-scale unit is maintained with very small arches or vaults, repeated one after the other in the same way as the sphere angle corner unit and spherical triangles unit. Two distinct methods appeared from this: the squinch method and the pendentive method, both are used as a transitional zone between various surfaces, and also as transitional zones between vertical and horizontal surfaces.

These innovations of the muqarnas continued to evolve, including the transition from the square to the circle and vice versa, and the construction derived from these two

unit methods. This is based on a series of innovations of the muqarnas as semi-circular recesses in a corner, connecting each other to a row in a small niche. The repetition and diversity, bulging out and deeply set, coordinating and tying together one after the other, is arranged so as to overlap with each row that is overlaid. A compound of the three niches is achieved with one on top of the other two. The muqarnas is used in order to hide the hard edges; as a transition zone, that cuts the vertical axis of the muqarnas in half, resulting in a semicircular recess covered with half a hemispherical vault (Sameh, 1970, p. 37) (Fig. 2.19).

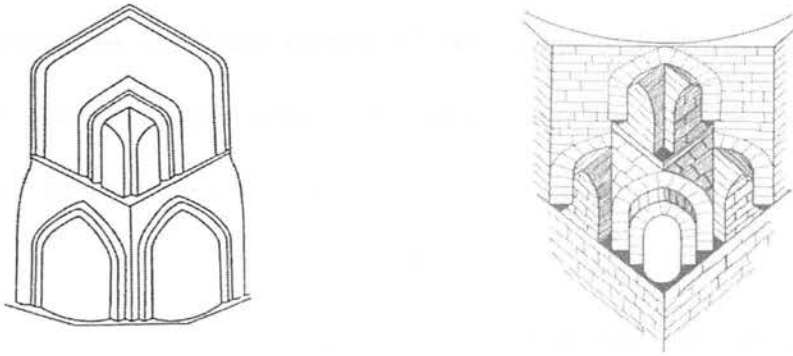


Fig. 2.19. The muqarnas is used in order to hide the hard edges

This resulted in an increase in the number of possible rows and is consistent with other structures. The muqarnas can be developed and constructed in proportion to any area, whether wide or narrow. Built on a line, the geometric shapes multiply in proportion with each other to develop the muqarnas structure in a given space, maintaining the relationships between the wholeness of the architectural elements. The innovation and aesthetic of the diversifying forms can be seen in relation to the link between them (Fig. 2.20).



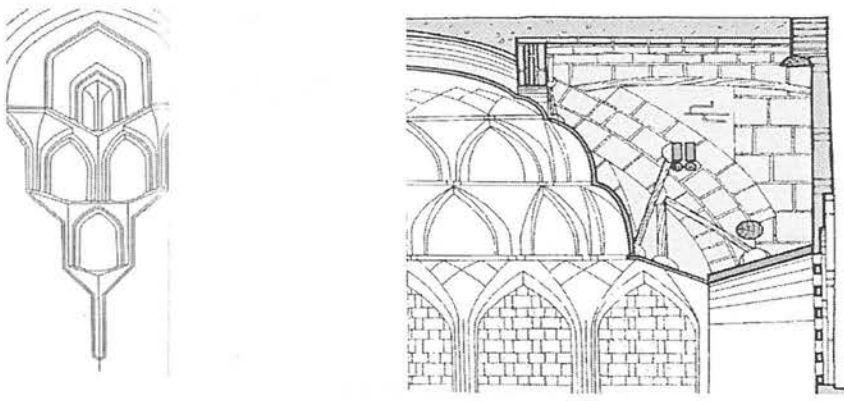


Fig. 2.20. The muqarnas structure in the corner.

In the current chapter, the author will shed light on this relationship. As indicated earlier, the muqarnas moulding corner of the *Ukhaydir* Palace came from the sophisticated Sassanian style which represented and provided new and typical characteristics. This was like a conch or a shell in a corner with two semicircular recesses covered with a hemispherical vault (Fig. 2.15). In the inner dome above the mihrab of the muqarnas of the *Qairouan* of the Great Mosque in Tunisia (AD 836–862), the muqarnas shows how the Sassanian style developed, becoming deeper and more curved, the surface of the geometrical lines coming out more. A double column supports the capital, which contains a muqarnas designed to join the pillars to the capital which supports the semicircular arch and dome (Al-Any, 1983).

However, the muqarnas of the tomb of *Imam Dur* (Fig. 2.16), which dates back to the *Uqaylid* period (AD 1085) in Iraq, developed from the Great Mosque of *Qairouan* in Tunisia. The vertical square construction contains four bastioned corners and is topped by a muqarnas dome, which is the earliest of the muqarnas type in Iraq. The bastions are divided into three zones by narrow bands; above an undecorated zone are two wider ones containing geometric brickwork, the lower is an intaglio of the one above. The plain curtain walls are bordered at the top with three rows or rhomboids



outlined in raised brick, and the dome is to a height of almost two-thirds of the height of the body (8.5m length and height of 12.5m) (Al-Any, 1983).

The tomb of the *Imam Dur* chamber is a square domed room; four corner niches create the transitional octagon on which the muqarnas dome rises in five corbelled zones culminating in a fluted cupola. Each zone consists of eight muqarnas cells decreasing in height towards the top.

The interior stucco decoration is traced to 'Abbasid' prototypes – conches, broken arches on brackets and lobed arches are surrounded by multiple wavy forms, creating an exuberant illogical effect of dizzying shapes (Philon, 1991 p. 251).

The muqarnas of the *Zumurrud Khatoun Tomb*<sup>vii</sup> dates to the Abbasid period, in AD 1202, in Iraq. "It can be seen to have developed from the tomb of the *Imam Dur* in Samarra, and is the second of its type in Iraq" (Philon, 1991 p. 251). It adopted the muqarnas in sphere angle corner niches, the inner space reflects the outer scheme of the dome, the transforming from an octagon into the sixteen figures of the muqarnas through the multiple division of the muqarnas areas. The centre dome culminates in a ribbed cupola minimised by muqarnas to a narrow aperture. In the eighth rows, eight of the muqarnas were reduced in number and continued to ten rows up to the top of the dome as a polygon, which led to an increase in the height of the dome to more than the height of the *Imam Dur* dome (8.5m length and height of 13.00m), and also allowed light to enter and create a starlit effect inside (Al-Any, 1983) (Fig. 2.21).

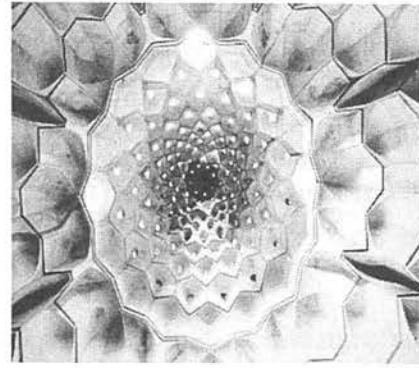


Fig. 2.21 - *Zumurrud Khatoun* tomb and inside

In this manner, the muqarnas can increase in sequences of rows which diminish in ascending order. They can increase their number, their plurality, their repeating rows, set-down and set-up together, bulging out and deeply set, on each other and over each other, in modules and coordinated groups, implemented in arches, capitals, windows, ceilings, domes, minarets, and mihrabs in a variety of shapes and forms with unique geometric arrangements. The author will present a review of the developments of the two original methods; the sphere angle corner squinch and the spherical triangle pendentive in Islamic art.

### 2.5.1. Evolution of a sphere-angle corner

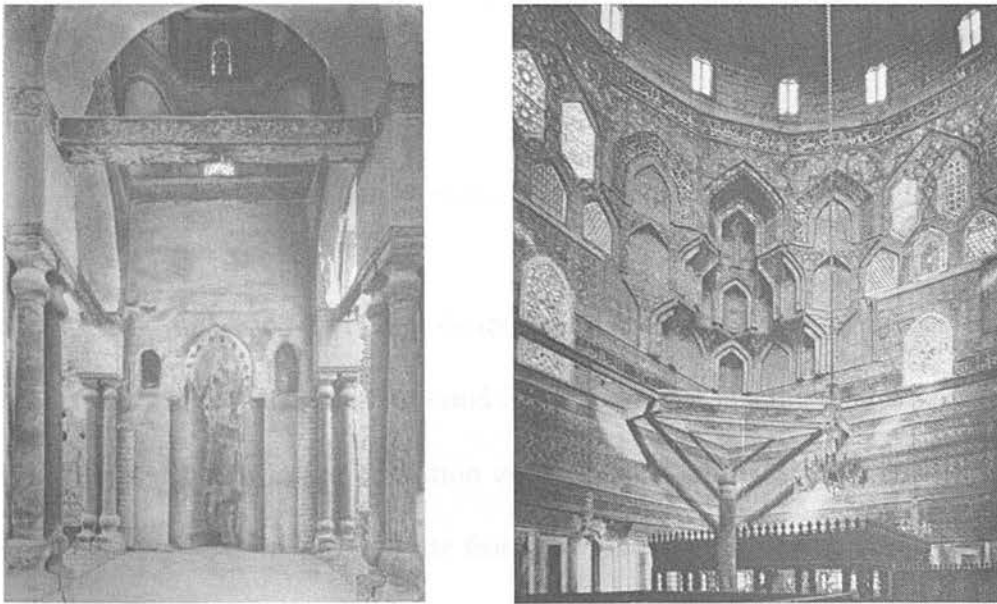
A sphere-angle is a particular dihedral angle; "it is the angle between two intersecting arcs on a sphere which are the equivalent to half a moulding of the concave niche in the corner sphere" (Ferraro, 1962, pp 42-44). In the construction of architecture it is a half of a semicircular recess in a corner, 'used to fill in the upper angles of a square room to hide the hard edges, and to support the form of niches. It was a right angle form of an octagonal and spherical dome' (Sameh, 1970, p.76), which was derived from the English term 'squinch' and the French *tromp*, it is used to create a half

moulding concave cone (Al-Any, 1983) (Figs. 2.12, 2.13), as the author explained in relation to the emergence of the muqarnas.

Researchers and archaeologists have differed in their opinions about this method of construction, which was used in a wide area of central Asia and the Middle East, "including Iraq and Persia, and how it was used in Byzantine architecture and the older Sassanian architecture" (Shafie, 1970, p.77). It is said to have existed from the western regions of Persia to the eastern regions of the Byzantine Empire, and it was used in the early Islamic era "in Iraq at the *Ukhaydir* Palace, which dates back to the Abbasid period AD 777" (Creswell, 1989, p. 128), and "the *Baghdād Gate of Raqqa*, in AD 772" (Creswell, 1979, pp. 244-245), and in the earliest monument at *Sāmarrā* – the *Bāb al-‘Āmma* – begun in AD 836, the *Jausaq Al-Khāgānī* (Palace of *Al-Mu‘Tasim* at *Sāmarrā*) (Creswell, 1989, pp. 333-334), and also in the tomb *Qubbat as-Sulaybīya* at *Sāmarrā*, in AD 862, constructed in the Abbāsīd period at the time of *Al-Muntasir Bi-Allah* (Creswell, 1979, pp. 372-373).

The significance of the muqarnas in the *Ukhaydir* Palace should be noted as an example of Sassanian architecture (Fig. 2.15). It is similar to the muqarnas of the *Bāb al-‘Āmma*; the main entrance of the *Jausaq Al-Khāgānī* Palace at Samarra. This is of significance as both have taken the Arab-Islamic type for the wall recesses, which have a semicircular niche or a half spherical dome in the corner, covered with a spherical angle corner which supports the dome. This type of muqarnas emerged in the building of the city of Samarra and it was found in the wall recesses characteristic of Islamic architecture.

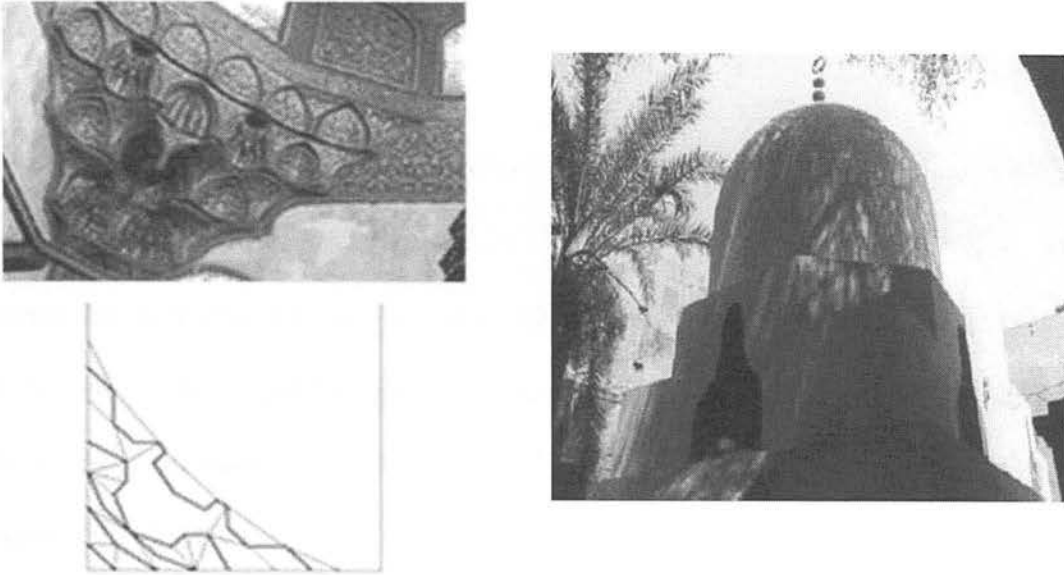
Thereafter, it moved to and spread with the eastern regions of the Islamic world. It appears in Egypt and the oldest examples of its use are found in the Fatimid period (Shafie, 1970), which was the beginning of the first simple muqarnas dome. It was a large form in the recess of a wall and had a concave composite raised arch, which is similar to the shape of an arched niche. The four corners supply part of the base of the dome. "This pattern has been followed in the building of domes with a transept, the dome in front of the *mihrabs*, and on the dome in the corners of the *qibla* wall in the *Al-Hakim* Mosque in AD 960–1003" (Lamie, 1984, p. 82), and in the *Al-Azhar* Mosque in AD 970–972 in Cairo (Fig. 2.22).



2.22. *Al-Hakim* Mosque, muqarnas plan and *Al-Azhar* Mosque

The muqarnas examples continued to multiply throughout Islamic architecture. For example, there were two rows in the dome of the tomb of Imam *al-Jaafari*, in AD 1120 in Cairo, and three rows in the dome of the *Al-Salih Nejame-din*, in AD 1249 in Cairo, and four rows in the dome of the *Bebars Aljashiker*, in AD 1306,

and nine rows in the dome of the *Faraj Bin-Barquqe*, in AD 1401 (Fig. 2.23), the author has visited this place, in October, 2002.



2.23. *Faraj Bin-Barquqe* and Imam *al-Jaafari*

The most significant period in the evolution of the muqarnas took place during the Mamluk period, which is the interim period in the history of Islamic Arab civilization. Therefore, the muqarnas in the transition zone of the Mamluke dome increased in number and continued to merge, starting from one muqarnas to rise up in a row to the top of the dome. In order to make the dome as wide as possible and for decorative purposes, in the inner and outer domes; number of buildings were constructed at that time, where kings, princes, sultans and the richest people struggled to rebuild mosques, schools, hospitals, agencies, khans (hotels), palaces, fountains and public fountains.

The Ottoman dome used the transition zones in the inner dome to compress the arch, and as explained, allowed the dome to be made wider as can be seen in the Ottoman mosques in Cairo, which used the muqarnas in the inside of the arches and in the transition zone, *Sinan Pasha Mosque*, in 771 AD. and *Mohammed Bey Abu-alDahb*, in 1774 AD. (abdulwahab, 1946, pp. 151-195).

The other evolution and spread in Ottoman architecture in the 14<sup>th</sup> century, was the tendency to stack rows of muqarnas in rows of diminishing numbers; they are constructed on three rows, then two and culminate with one row. An example of this can be found in the Great Mosque, in Bursa, the *Üç Şerfeli Mosque*, AD 1438–47, in Edirne, the *Sûleymaniye*, in AD 1550–7 and the *Sultan Ahmet*, early 17<sup>th</sup> century, in Istanbul (Fig. 2.24) (Takahashi, 2005).

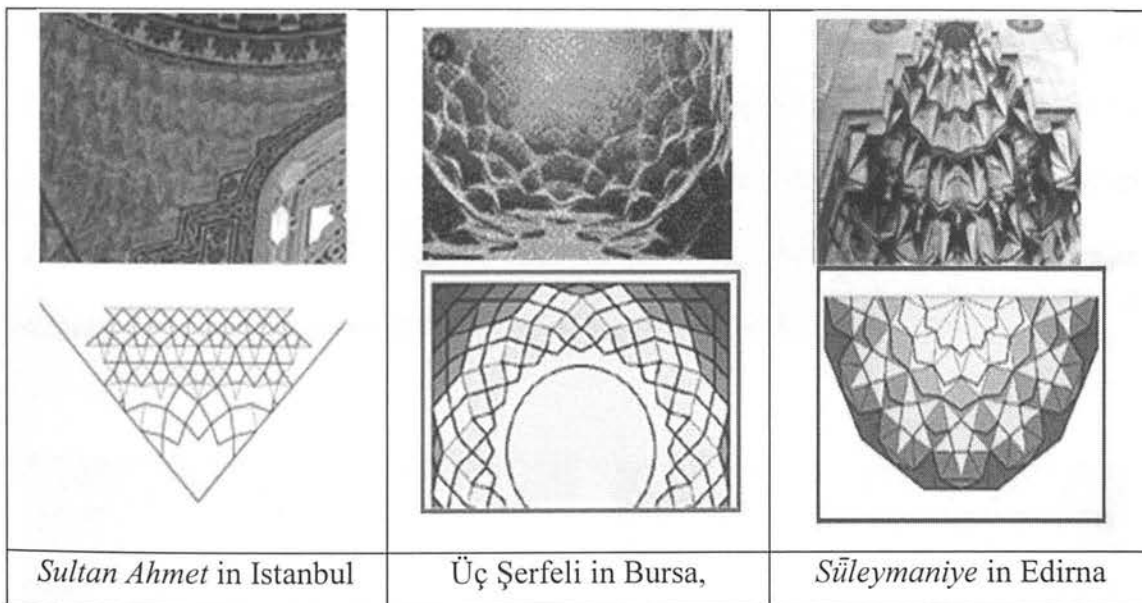


Fig. 2.24. Increasing layers of muqarnas in the Ottoman architecture.

In Seljuq and Tīmūrid architecture in Anatolia, "the muqarnas was used on the inner dome as a transition zone" (Aslanapa, 1971, p.408) "presenting a new distinctive style

in the evolution of the muqarnas" (Rihawey, 1990, p.165). This style spread through many lands; the Seljuq established a powerful state occupying land in Turkistan and Iran. It also spread throughout northern central Asia, north Africa into Egypt and Morocco, to Islamic architecture where the muqarnas became apparent and visible as a constructional element in the dome rather than a transition zone in the corner; it became a decorative element covering inner domes, arches, mihrabs, corbel balconies and minarets.

In general, reconstructions of a sphere angle corner developed into a diversity of shapes and forms using new materials. A simple construction of the structural design of a semicircular recess in the corner was used in order to fill in the upper angles of a square room to hide the hard edges. For example, in the eastern regions of Iraq and Iran, the muqarnas was used as a decorative motif consisting of three niche fragments. Baked blocks were used at a corner in the dome chamber and the principal *īwān*, on the transition from the wall structure in the dome, as can be seen in Iran in the *Masjid-I Jāmi* and at the Great Mosque/Friday Mosque in *Isfahān*. During the *Abbāsid* to *Safavid* period in the 8<sup>th</sup> – 17<sup>th</sup> centuries (Fig. 2.23), this style became a popular technique in adapting existing Persian buildings (Takahashi, 2005).

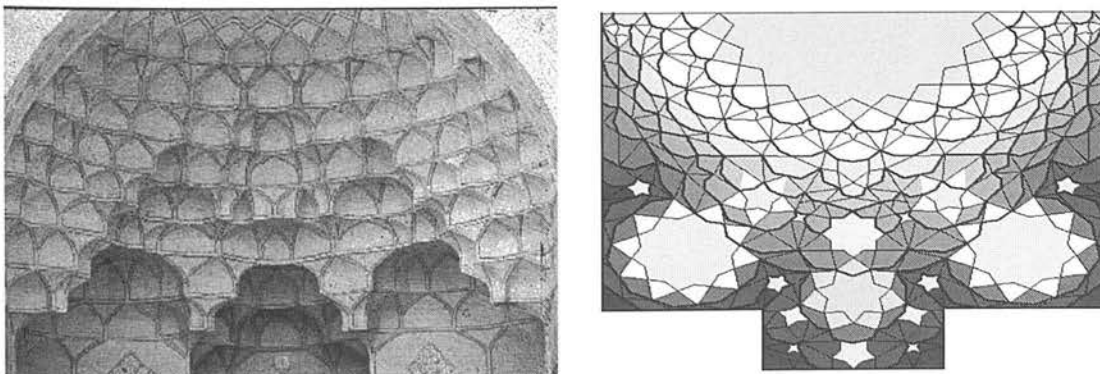


Fig. 2.24. *Masjid-I Jāmi* and plan



Another example of the Saljuq period style from the 11<sup>th</sup> and 12<sup>th</sup> centuries can be found in the Qazvīn/Friday Mosque, in Ardeestan, and at the Royal Mosque (Masjid-i-shah), in 1612 AD, and the Mosque of *Shaykh Lutallāh*, in 1617 AD, in *Isfāhān* (Hutt, 1991) (Fig. 2.25).

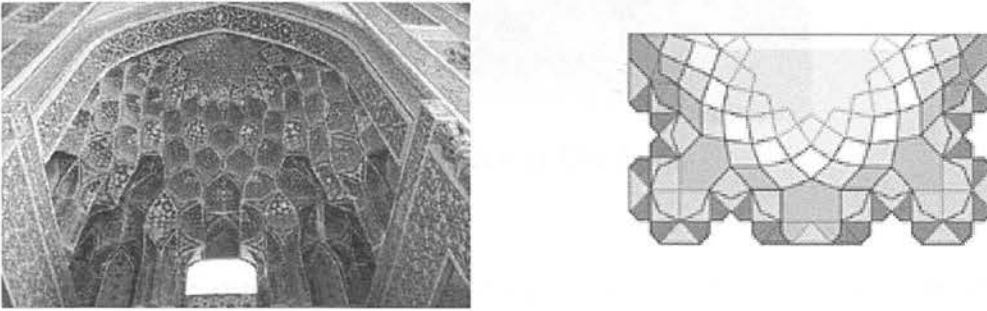


Fig. 2.25. Masjid-i-shah and scale

That innovation of the new muqarnas in the Damascus region during the Saljuq period can be seen in the magnificent example of the Tomb of *Nur Al-Din* dome, in AD 1172, which is distinctive (Fig. 2.26); the muqarnas cover the inside of the dome, which includes niches containing small windows and interrelated weaved vaults, which include double-barrel vaults, a shaped ornamental structure, with the cupola consisting of a conch dome on the top of the roof dome.





Fig. 2.26. *Nur Al-Din dome*

This structure can also be found in the *Beemare-stan*<sup>viii</sup> *Al-Nuri* mosque, in AD 1154, in Damascus, at the entrance into the lobby of the *Darkah* dome, which consists of a square hall covered by a dome. On both sides are small *īwāns* which use muqarnas in the transitional areas to connect the niches to the dome, forming the intersection of two double vaults which cover the niche in the northern and southern walls. The muqarnas is shaped on both sides; the converse exterior conical dome reflects the concave interior. The shape of the ornamental muqarnas from the inner dome shows the enriched block or horizontal bracket of the muqarnas. This inner and outer dome illustrates the moulding structure with a regular arrangement, decreasing as it ascends (El-Basha, 1988) (Fig. 2.27).



Fig. 2.27. *Al-Nuri* mosque

Another example in the North African region of Tunisia and Morocco used the muqarnas as a decorative motif which was of Eastern origin, as the author has explained previously. The evolution of a sphere angle corner is represented in the great mosque of *Qairawān* in AD 863, in Tunisia, developed from the *Ukhaydir* Palace in Iraq (Fig. 2.28).

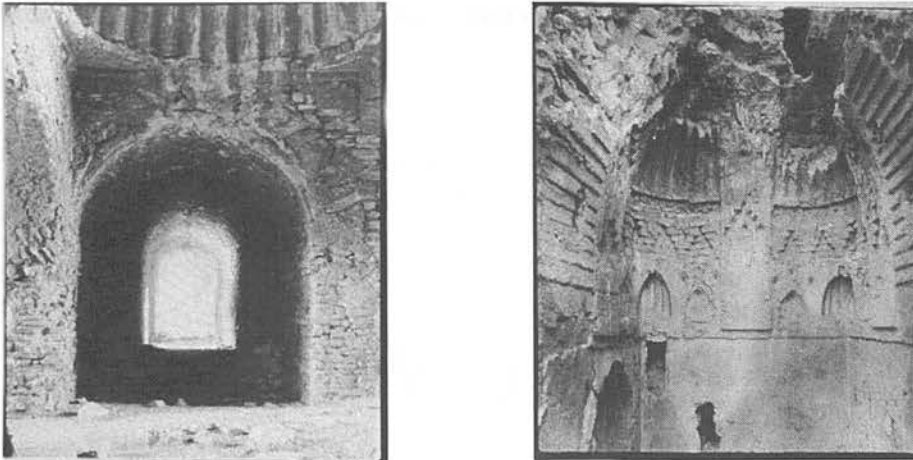


Fig. 2.28. *Ukhaydir* Palace from inside

The octagonal zone of transition on the setting dome in front of the mihrab is formed by eight semicircular arches which spring from an engaged entablature, and form a circle through the use of eight squinches.

The eight arches form shallow panels, and the four which come above the corners are pierced by shell-like squinches of nine lobes, and their nine-lobed outline is repeated in the four panels which alternate with them (Creswell, 1989, p.328).

The sphere angle corner was further developed in the Great Mosque of Cordoba in AD 755 in Spain, and can be found in the *Zaytuna* mosque, AD 1153, in Tunisia; and in the muqarnas dome on the Sfax of the Great Mosque, AD 988, and in the QAL'A of the *Banī Hammād* Palace and Tower, AD 1100, in Tunisia (Michel, 1991, pp. 219–220).

### 2.5.2. Evolution of spherical triangles

A spherical triangle "involves corner angles and the angle formed at the intersection of the arcs of two great circles" (The American Heritage Dictionary, 2007) (Fig. 2.29).

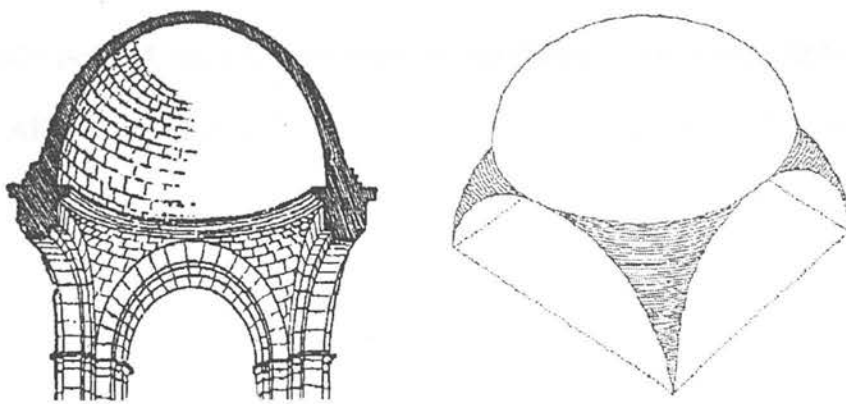


Fig. 2.29. Spherical triangle (Pendentive)

In this study, the spherical triangle is used in an exterior circle construction to join it to an interior square, where it is a triangular segment of a sphere which tapers to three

points and spreads at the top to establish the continuous circular or elliptical base needed for the dome. In masonry, the pendentive thus receives the weight of the dome, concentrating it at the four corners where it can be received by the piers beneath. Pairs of pendentives were developed as the method of corbelling in the corners of a square room; they have been employed as a transition zone from the wall to the circumscribed circle. The pendentives join the two inner forms of the construction; each façade of the building has two tiers of three-arched niches hollowed out of the principal mass.

The innovation of the pendentive form of roofing became popular in Islamic buildings and was produced "in the Muslim lands from the fifth century AD, when they were first used by the Romans in the Syrian region, during the Byzantine Empire" (Goodwin, 1991, p.251). They influenced the subsequent civilisations and their use spread from region to region (Shafie, 1970).

Another early example of this feature of the spherical triangle can be found in Islamic architecture, as the transverse arches leap from low pilasters, and are remarkable for being slightly pointed, as can be seen in the *Qusayr 'Amra* (the little palace of 'Amra), in AD 711, located in the east of *Ammān* in Jordan (Creswell, 1989, pp. 105-107). The exterior of *Qusayr 'Amra* corresponds exactly to the spatial arrangement of the interior; it is to be found in the warm room that in turn leads to the "hot room", which carries a dome on pendentives with four windows, which in turn leads to a "warm room" covered by a cross vault and has a raised floor to allow for the circulation of warm air (Fig. 2.30).

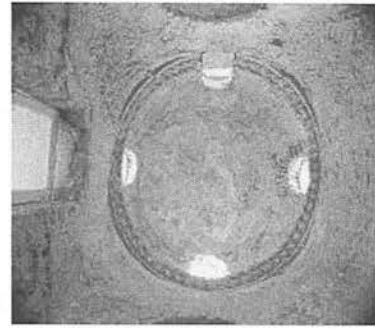
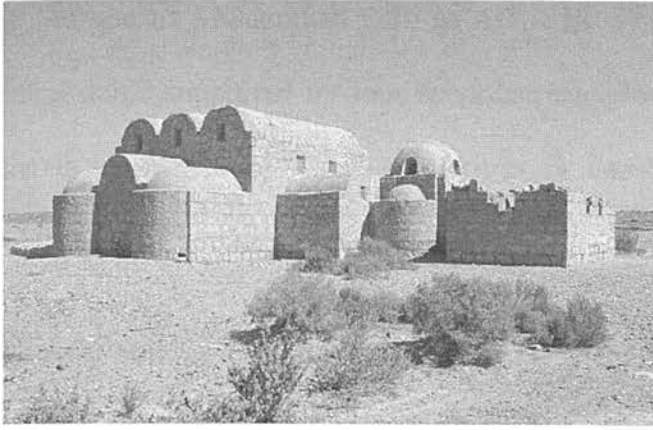


Fig. 2.30. Qusayr 'Amra

The other earliest example, as can be seen in the *Hammam al-Sarakh*, 2<sup>nd</sup>/8<sup>th</sup> century (Creswell, 1989, p. 164), in Jordan, the plan of the building is strikingly similar to the *Qusayr 'Amra* vaulting systems: a tunnel-vault, a cross-vault, and a dome. (Fig. 2.31).



Fig. 2.31. The *Hammam al-Sarakh*

Another example of the spherical triangle can be found in Egypt, in the years AD 1087 to 1169, in the Fātimid period, in the *Bāb an-Nasr* (Gate of Victory), *Bāb al-Futūh* (Gate of Deliverance), and *Bāb Zuwayla* when the Fātimid vizier Bader al-Hamālī replaced the original mud-brick fortifications of the city with stone walls (Michel, 1991, p. 224). Also, in the Mamlūk period, at the Mosque-madrassa and Mausoleum of *Qānsūh al-Ghūrī*, AD 1503, in Cairo, and in the Ottoman influence at

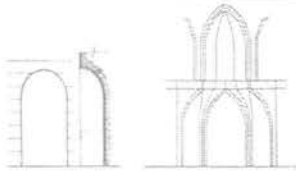
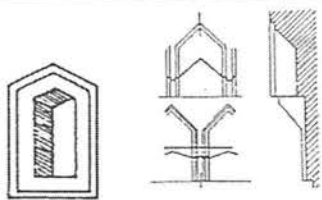
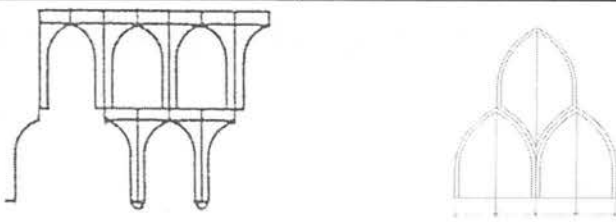
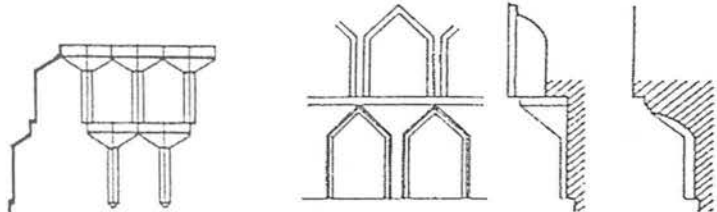
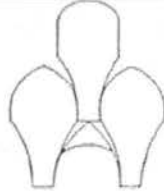
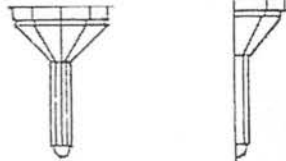
the Mosque of Muhammad 'Alī, in AD 1830. Thus, the Cairo mosque has a large central dome supported by four spherical triangles in the corner of the square hall. This is confirmed by close similarities in construction and decoration with the architecture of northern Syria and Iraq.

The most striking example of the spherical triangle and decoration is to be found in buildings in Turkey: the Great Mosque *Üluc-Jāmī* in Bursa, Anatoli, built at the end of the fourteenth century; in the complex of *Süleymaniye*, in AD 1557, built in the Ottoman period; the complex of *Sultan Ahmet*, in AD 1616; and the *Nurosmaniye* complex, built in the mid eighteenth century, in Istanbul. Another example found in Baghdad, in Iraq, was built during the Ottoman period, in the *al-Qumriyya* mosque, in AD 1228 (Michel, 1991, p. 247). A further example showing how the spherical triangle and decoration was developed as a method of corbelling in the corners of a square room, which is similar to the curved muqarnas in Iraq during the Abbāsīd period, can be found in Baghdad, in the tomb of *Sitta Zubayda*, in AD 1179. However, many important buildings featuring this style of decoration have been lost through demolition, war and natural disasters.

## 2.6. Types of muqarnas

Through the author's extensive study of literature on the muqarnas, he has observed various forms of arches in different types of muqarnas, which describe the categories that are used for a multiplicity of purposes. So, what could pass from one category to another sub-type means that a plurality of multi-types would follow from one category example. This can be organised into four main categories divided into sub-types, all-inclusive and all-embracing, incorporating the types and styles relevant to

the whole study. The following will deal with the different types, based on the construction and installation forms of the extrados and intrados of the arch, which reflect the content of this coverage. These types are as follows (Fig. 2.32):

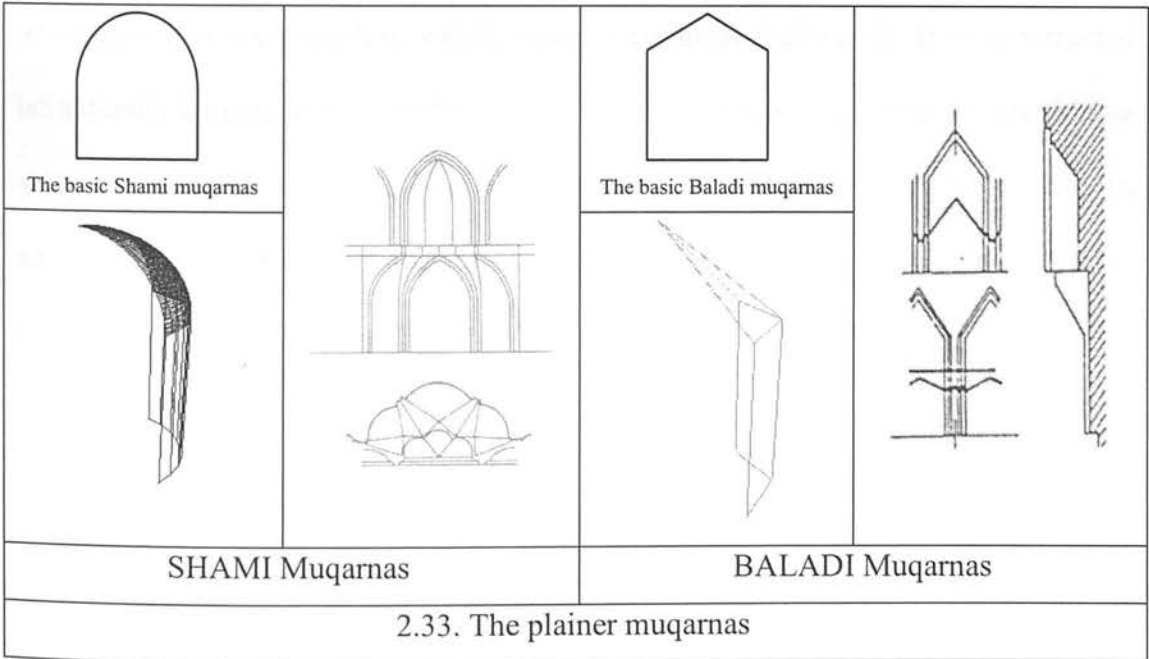
I-Plainer Muqarnas					
	SHAMI Muqarnas		BALADI Muqarnas		
II- Concave composite Muqarnas					
	SHAMI Muqarnas				
III - Prismatic composite Muqarnas					
	BALADI Muqarnas				
IV - Stalactites					
	Ceiling cascade		Wall mounted		
Fig. 2.32 - The muqarnas types					

In the following four paragraphs the author presents the four types of muqarnas which he will use as a case study as the basis of his intention to create and produce a

software program version of the muqarnas (see chapter five, the Generator of Muqarnas program).

2.6.1. Plainer muqarnas

The plainer muqarnas is usually in the form of a staircase, which comprises three cross vaults which create two barrel vaults side by side, with the third on top, divided into grades in the same proportion as the structure of the graded axis. The best arrangement for plainer muqarnas cross vaults is that the vertical axis divides the central heads of the arches into two sections; the other grade is located underneath, proportionately, the equal span of the vault (Kamel, 1994). Most researchers are agreed on the intentions of the sphere angle corner and the spherical triangle in the plainer muqarnas, namely, in order to support the hemispherical dome. Since the muqarnas is a piece of the staircase, which is built in the same proportion, a stair is composed of more than one step, and repeated one after the other, and divided into grades which fit into the structure of the graded axis which has two types, SHAMI or BALADI (Fig. 2.33).





### 2.6.2. Concave composite or Shami muqarnas

The plan projection of the concave composite muqarnas elements consists of simple geometric forms; the cylindrical in-depth and the arched form of the muqarnas is a composite of a group of concave and convex vaults in the form of spherical geometry, repeated one after the other in the same way as the sphere angle corner unit and spherical triangle unit (Kamel, 1994). They consist of a set of small moulded concave niches known as SHAMI muqarnas.

The term *shami* muqarnas, or round arch, is used to refer to a semi-circular arch with each arch protruding as it reaches the apex, a composite of a group of concave shapes in the form of plane geometry, used as buttressing in the construction of flying buttresses and also in vaults, repeated one after the other, like lacework or molecular cells. The *shami* muqarnas, also known as *Quadrant arch* or *al-Halabi* (Aleppo)<sup>ix</sup> (:<<http://www.islamic-art.org/Glossary>>). Muqarnas is a compound of three niches and is achieved by constructing one row on top of the other two niches. It has a round or semicircular arch window which forms a complete half-circle. It is constructed latitudinally by hanging or stabilising some of the layers or constructive lines side by side, in which small niche-like components are combined with each other in successive layers to enclose a space and to produce surfaces rich in three-dimensional (3D) geometric composition (Fig. 2.34).

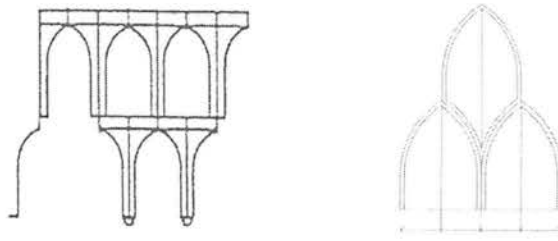


Fig. 2.34. Shami muqarnas

### 2.6.3. Prismatic composite or Baladi muqarnas

The plan projection of prismatic composite muqarnas elements consists of simple geometric forms: "the rhombus and the square" (Kamel, 1994, p.35). It consists of a set of small moulded prismatic niches known as Baladi muqarnas. The term Baladi muqarnas, or keel arch, is used to refer to an arch with each arch protruding until it reaches the apex, in the form of a pointed arch. The keel arch of Baladi muqarnas, also known as an *arabi* muqarnas, is a compound of three niches and is achieved by constructing one row on top of the other two niches, and has a pointed arch window resulting in a prismatic form of the biped and almond that are complementary figures that derive from a rhombus. Other elements like the half square (cut along the diagonal), the half rhombus (an isosceles triangle with the shorter diagonal of the rhombus as its base), the rectangle including a jug shape in proportion to the square, are repeated one after the other in the same way as the cells of a honeycomb (Fig. 2.35).

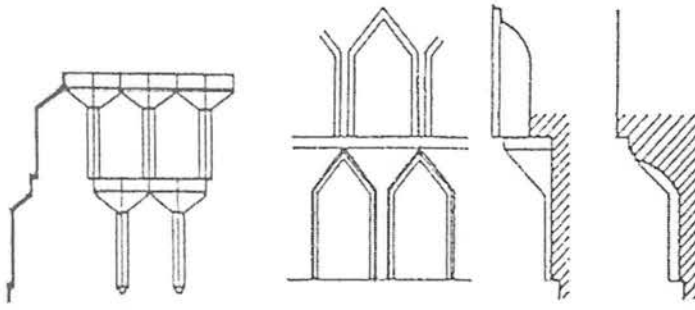


Fig. 2.35. Baladi muqarnas

#### 2.6.4. Stalactite muqarnas

The first thing to be looked at in muqarnas work is the situation, or environment in which the muqarnas finds itself. This gives some indication of the overall feeling of the muqarnas, and how it is related to the physical situation. The two vaults (stalactites) are side by side, they are constructed with arches in the middle, and the tail of those arches fills the empty space. At ground level, it has four forms with a tail (triangle, square and star) which support the upper part of this composite shape. There are two types which work in the double-barrel vault and they overlap as follows:

##### 2.6.4.1. Cascade of stalactites

A cascade of stalactite muqarnas is a roller arch designed where the small vault arch is below the arch or dome rather than on top of it; "the equivalent to half a moulding of the concave niche in the sphere angle corner" (Kamel, 1994, p.37) (Fig. 2.36).

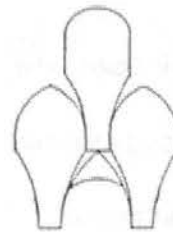


Fig. 2.36. Cascade of stalactite muqarnas

#### 2.6.4.2. Wall-mounted muqarnas

A wall-mounted muqarnas is a roller arch design where the small vault arch protrudes from the wall; "the equivalent to half a moulding of the concave niche in the sphere angle corner" (Kamel, 1994, p. 37) (Fig. 2.37).

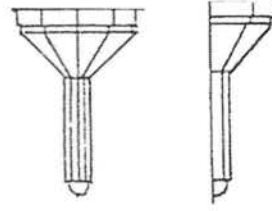


Fig. 2.37. Wall-mounted muqarnas

### 2.7 Utilisation of muqarnas

The muqarnas is distinguished in Islamic architecture as having certain characteristics; it is important to make a significant distinction between the methods used in the muqarnas as a decorative system and the forms in which it is applied in architectural elements. The muqarnas depends on the extent of uniformity in the construction and aesthetic decoration, and links together with the whole elements of the building. It can be used both as an architectonic form, because of its relationship to vaults, and as an applied ornament, because of its decorative characteristics

The muqarnas was created by Islamic artists and designers who used the required design, conforming to the substantive work as a whole. The proportion and the units link together like components and are combined with each other in successive layers to enclose a space and to produce surfaces rich in three-dimensional geometric compositions. The muqarnas consistently link together with architectural and decorative elements in Islamic buildings, and there are many examples which typify this method of combining the practical aspects of building with aesthetics and art.

Architecture has traditionally referred to the art and science of designing buildings, and is concerned with the product of a design or the act of designing as well as the artistic traditions. It refers to the overall structure of the system, which is the idea that architecture embodies a coherent set of organisational principles and objectives, guiding the design of each aspect of a complex structure. A building sets large-scale principles such as the combination of the visible symbols of each architectural element in relation to the size and proportion of the structure. The magnificence of a building project acts as the basis for the designer's plans as applied in the inclusion of the muqarnas units in Islamic architectural elements such as arches, capitals, domes, minarets, portals, façades, mihrabs, minbars and furniture, in a variety of shapes and vaults, as described in the following sections.

### **2.7.1. Implementing of the muqarnas in arches**

The variety of types of arches that were used in Islamic architecture, in many different regions, included new forms of arches, which were derived from the revival of extinct forms, the preservation of others, or the evolution of the original type. The muqarnas in an arch is a curved structure used as a support over an open space and as an ornamental frame of projecting niches in a wall, or supporting structure. It hides the transition zones between various surfaces of an arch frame, or was developed from an arch constructed in part as decoration. There are two types of muqarnas in the arch:

#### **2.7.1.1. Implementing of the muqarnas in the intrados arch**

The intrados arch of the muqarnas is a multi-centred arch whose curve consists of several arcs of circles or angles at their intersections; it is similar to a scallop arch or cusp arch. It is curved by muqarnas or stalactites vaulted in the intrados arch, with

constructed arches in the ending of these arcs, which are side by side. The tail of those arches fills into the empty space. Thus the muqarnas in the intrados arch evolved by development from corbels in the small stalactite vaults of arches, whether a semicircular or a horseshoe arches. It became a popular style in Islamic buildings, the oldest example being found in the *Baghdād Gate of Raqqa*, in AD 772, and in the *Ukhaydir Palace*, in AD 777 in Iraq (Creswell, 1989) (Fig. 2.28).

The intrados arch of muqarnas moved to the west countries of North Africa, and its sophisticated use is evident in Moroccan and Andalusian styles, which represented and provided new types of muqarnas, and with widespread stalactites vaulted throughout building elements (e.g. halls, rooms, bathrooms and courtyards), (Fig. 2.38).

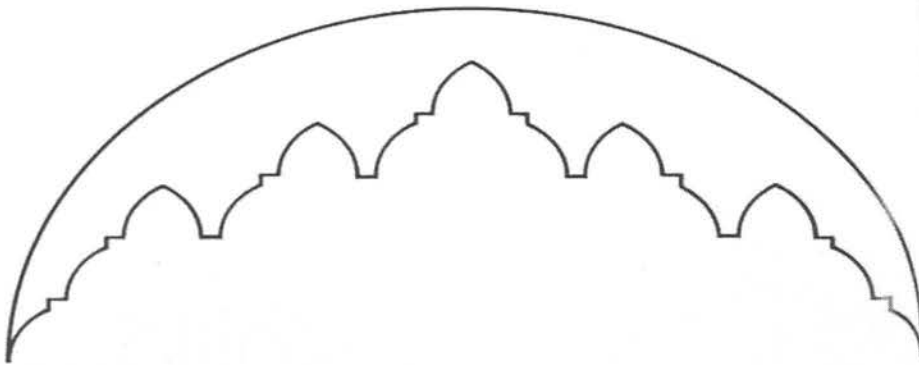


Fig. 2.38. intrados arch of the muqarnas

The stalactites vaults became the characteristic decoration in the common palaces and public buildings, such as the palaces of the Alhambra, Granada, Spain and the western countries of North Africa (Fig. 2.39), the author has visited this place, in March, 1995.

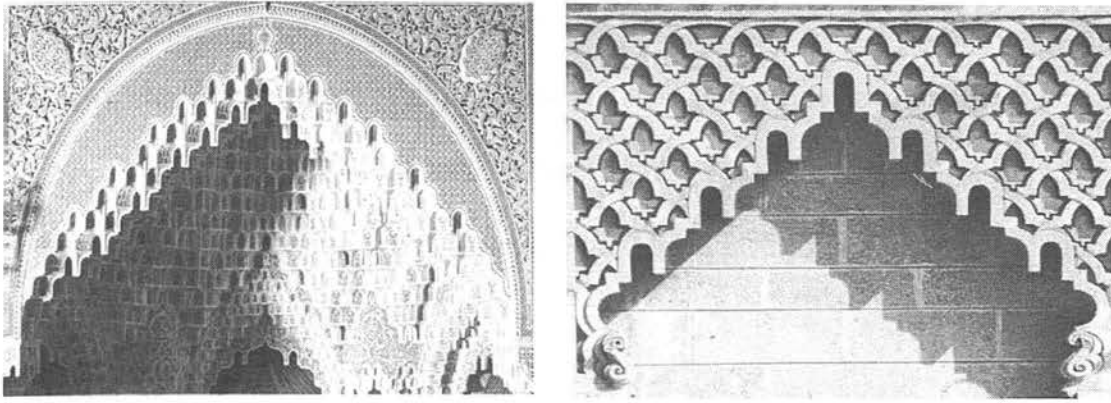


Fig. 2.39. The intrados arch of muqarnas in Morocco

#### 2.7.1.2. Implementing of the muqarnas in the cascade arch

The suspension muqarnas arch is supported by an abutment arch and is a composite of a muqarnas arch whose construction consists of two intersecting lines, an oblique line at an angle of  $60^\circ$ , and other upper intersecting lines at an angle of  $120^\circ$ . It is the same as the broken arch with a gap at the top where the gap is usually filled with a small muqarnas volute at the right and left and inside the arches up to the end arch; it gives beautiful proportions in terms of composition and sequence (Fig. 2.40).

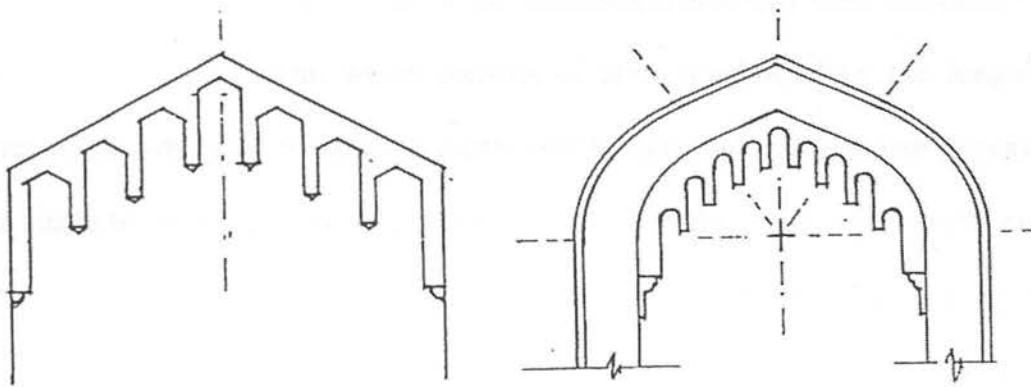


Fig. 2.40. The suspension muqarnas arch

The suspension muqarnas arch is a multi-centre arch whose curve consists of several small hung down vaults, which are tangential at their intersections under the surface

of the arch. They have the same molding concave niches at the centre of the arches, and also, the same intrados arch of muqarnas used in the front and around the arch frames, as small recessed windows in the arch walls. These types of arches were used widely on the west region countries of North Africa in the common places, public buildings and palaces (Fig. 2.41).

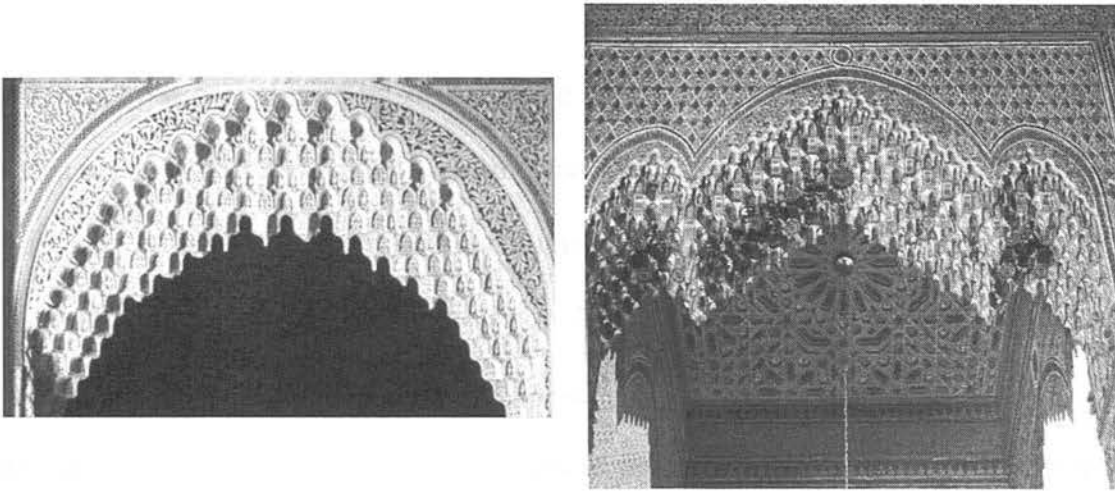


Fig. 2.41. The suspension arch of the stalactites vaults in North Africa

The construction methods of the suspension muqarnas arches have been described by Wilbrun (1955), as a system which consists of rows constructed by the hanging together of the whole of the arch elements side-by-side, such as standard concave niches, made by wood, and all the components are combined in successive rows and in different formations and in different scale of all construction. This system of inserting concave moulded wooden niches in and under the arch, to hide each row of the arch system, gives the value of the cascade muqarnas arches. The author will shed light on the implementation of the muqarnas in facades and recesses panels of windows and in entrances.



### 2.7.2. Implementing of the muqarnas in capitals

A capital in architecture is the top part, capstone, or head of a column or pillar (Capital, Glossary, 2006). It can be either freestanding or engaged (attached to a wall). The capitals are important function in transmitting weight from the superstructure to the top of the column, and the artisans were decorated by muqarnas decorations in the upper part of a column.

The muqarnas capital used by Arab-Islamic builders consists of a system of supports and decorative features, usually ornamented by molding or carving or both. It was distinguished by Islamic architecture columns as unique and characteristic capitals. It is existing with various types depend on the columns style (e.g. cylindrical-body columns, polygonal columns and octagonal columns). The muqarnas capitals are decorated with one, two or three superimposed rows of carved shafts of a column or a pier and a beam, arch, or vault, around the capital as follows:

1. Octagonal-body columns with one row on the muqarnas capital, which has a carved shaft on the upper parts and a fragment on the lower parts, and is decorated with copper (Fig. 2.42).

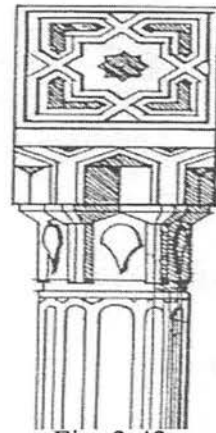


Fig. 2.42.

2. Cylindrical-body columns with one row on the muqarnas capital (Fig. 2.43).

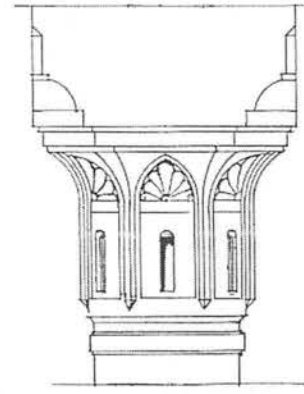


Fig. 2.43

3. Octagonal-body columns with two rows on the muqarnas capital, which has an octagonal basis around the capital to fit with the capital (Fig. 2.44).

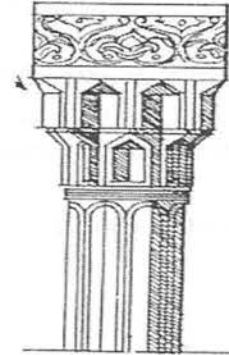


Fig. 2.44

4. Cylindrical-body columns with two rows on the muqarnas capital, which has a belt circular base around the columns' body, with carved vaults which start at the lower parts of the rows and end at the upper parts of the muqarnas capital (Fig. 2.45).



Fig. 2.45

These model were used widely in Islamic architecture on columns capitals, there models can be found in the portal of the Mosque and Hospital, in 1229 AD, in *Divriği*, in Turkey from the *Mengüjükid* period, also in the Caravanserai, in 1229 AD, in *Aksaray*, in Turkey from the Seljuq period (Michel, 1991), and in the lobby of the, *al-Firdawsi Madrasa*, in 1234 AD, in Aleppo, in Syria from the *Ayyūbid* period, and it is

made by stone and each capital consists of three rows of muqarnas, , and also, in the mosque of *Dervīsh Paşa* in 1574 AD in Damascus (Atlasa, 1956).

Other examples of the muqarnas capital were founded in Egypt in the portal of the *al-Sultan Hassan* mosque, Cairo, 1356 AD (Lami, 1984, p.78). Another example can be found in the capital columns of the mihrab which were made of marble from the *al-Muʿyyad Shaykh*, in Cairo, 1420 AD (Abdulwahab, 1946). The other example can be found also, in the capital of the portal of the *Khānaqāh* and *Mausoleum* of *Fāraj bin Barqūq* in AD 1409 (Lamie, 1984, p. 82). The other example also, it is found in *Ālī Qapu* palace in Isfahan, Iran from the early 17<sup>th</sup> century, also in the Friday Mosque in Kerman, from 1349 AD. (Abdulgawad, 1970, p.96).

The most striking example of the muqarnas capital is to be found in the columns of the *al-Hambrā* palace, in Granada in Spain, from the 13<sup>th</sup> and 14<sup>th</sup> centuries (Fig 2.46).

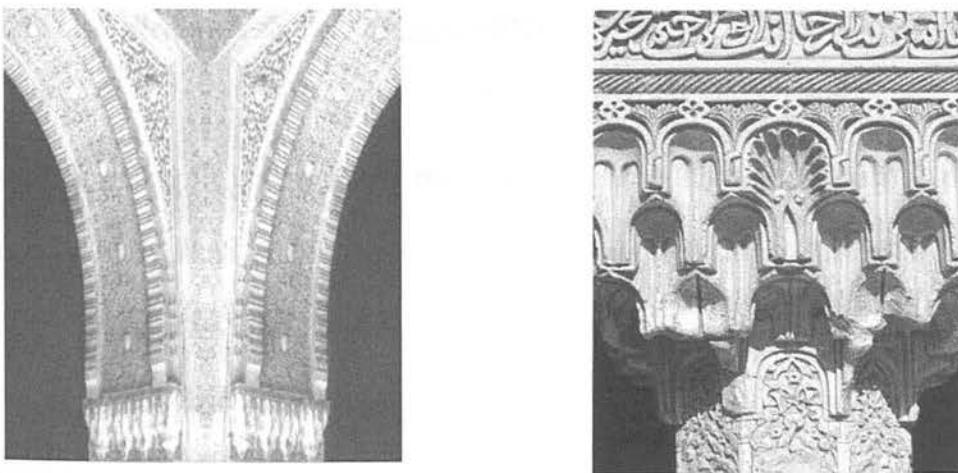


Fig. 2.46. the muqarnas capital of *al-Hambrā* palace

Another example of the muqarnas capital is in the Anatolian region, where "it became a popular style in Ottoman buildings, after they used the Byzantine columns and

capitals in the early Seljuk period mosques" (Marzoq, 1974, p. 26). However, the Ottoman masons and artisans developed and made increasing use of the muqarnas capital, such that

They became standard in the Ottoman period, in particular in Turkey, where they invented a new type, in the form of a spherical triangular style, for example, in the *Süleymaniye* mosque, in Istanbul, from AD 1550–1557 and a capital of the *Sultan Ahmet* mosque in AD 1609, in Istanbul (Abdulwahab, 1946, p.148).

The popular style in Ottoman buildings of a muqarnas capital with a small muqarnas vault, which is derived from a form of the pendentive method, was used primarily as internal cladding for curved capitals by an elaborate domical construction on capitals and ledges, and was "produced in the architecture of the Islamic world from the fifteenth to the eighteenth centuries" (Sims, 1991, p.110). The muqarnas capital with a spherical triangle was "commonly used in Ottoman architecture" (Unsal, 1959 p. 36). An example can be found in the muqarnas capital of the *Sultan Murad sacand* Mosque in AD 1451, in a capital of the *Sultan Ahmet* mosque, in AD 1609 in Istanbul, and in the *Süleymany* Mosque in Konya in Turkey from the seventeenth century (The author has visited this place, in June, 2000).

Another example, as noted by the author, can be found in a capital of the Holy mosque in Makkah in Saudi Arabia, (the author grew up and has been living in this city), which was built in the Ottoman period. In construction, it consists of an octagonal-body of columns with one row on the muqarnas capital in the transition from the square and the circle. This became a popular style in order to fill in the upper angles of a square room to conceal the hard edges of a right-angle form of a spherical triangle dome (Fig. 2.47).

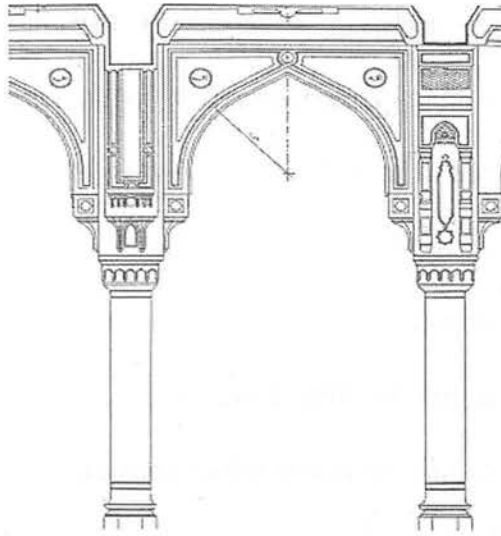


Fig. 2.47. The muqarnas capital of the Holy mosque, in Makkah

Another progression in terms of column solutions of the muqarnas capital is to be found in the corner of a portal called the soft corner. It is decorated with one or two superimposed rows mounted on the column, and at the corners of the capital there are small muqarnas volutes. An example can be found in the soft corner capital in the corridor of the Abbasid Palace in AD 1200, in Baghdad (Fig. 2.48).

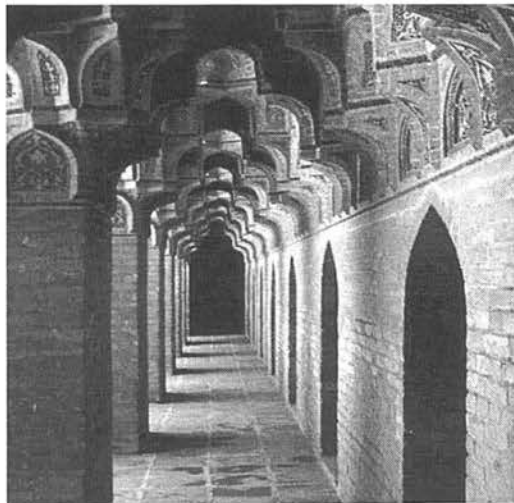


Fig. 2.48. The muqarnas capital in the corner

### 2.7.3. Implementing of the muqarnas in domes

The idea of the muqarnas is related to the emergence of the dome and is a transitional zone between various surfaces of horizontal and vertical angles in a variety of shapes and forms with unique geometric arrangements, as well as being used to hide hard edges. The author discussed this previously in relation to the emergence of the muqarnas (page 25) and to the generative units of the muqarnas (page 41). The transition zone from the square form to the octagonal and circular shapes on which a dome stands is the result of approaches where two methods were adopted; namely, the pendentive and the squinch.

**The first method:** The spherical triangular method, called 'pendentive', is where a pendentive, "an inverted cone, has its point set low down into the corner and its base is at the top, providing a platform for the dome"(Naser, 1971, p. 68). "It is a constructive device permitting the placing of a circular dome over a square room or an elliptical dome over a rectangular room" (Rasch, 1985, p. 129).

It is an ideal model which uses the corner spherical triangles to support the central dome, so it receives the weight of the dome, and thus the four arches leave between them four spaces, resulting in somewhat concave constructions with the weight concentrated at the four corners where it can be supported by the piers beneath. The transition zone from the wall to the circumscribed circle involves spherical triangles in order to join the two inner forms in the construction, the top of which has the form of a circle, which is quite suitable as a basis for the dome. Each façade of the pendentive has two tiers of three-arched niches hollowed out of the principal mass (Fig. 2.17). The portals in the centre of each side are a magnification of these niches.

They are, in their turn, each filled by miniatures of themselves, and with the repetition of these small spherical triangles included at each of the corners, a complete unity is derived.

The earliest existing example of the pendentive dome in the Muslim world can be found in *Qusair Amra* in the Jordan desert (Fig. 2.59). This example goes back to the Umayyad period (AD 661–750). Other examples of the spherical triangle can be found in Egypt, in some Fatimid period buildings, such as the *Bāb al-Futūh* (Gate of Deliverance), *Bāb an-Nasr* (Gate of Victory) of *Badr al-Jamālī* in AD 1087, *Bāb Zuwayla*, in AD 1092, and in the *al-Aqmar* mosque, in AD 125, in Cairo (Lamie, 1984, p. 82). Other examples can be found in the *Bahri* Mamluk period in the dome of the mausoleum of sultan *al-Manṣūr Qalāwūn* in AD 1284, and in the dome of the mosque of *Amir Aqsunqur* in AD 1347. It can be found, also, in the *Circassian* Mamluk period in the domes of the *khanqāh* of Sultan *Faraj Ibn-Barqūuqe*, AD 1401 (Fig. 2.49), the author has visited this place, in October, 2002. Also, in the *madrasa* and *khanqāh* of Sultan *al-Ghūrī*, in AD 1503 in Cairo, and in the mosque of *Muhammad 'Alī* in Cairo, from AD 1830 under Ottoman influence (Abouseif, 1989).

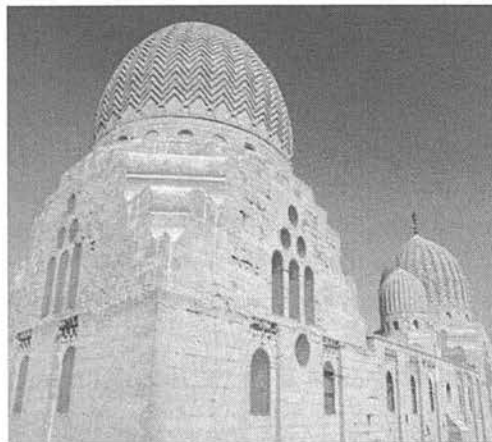
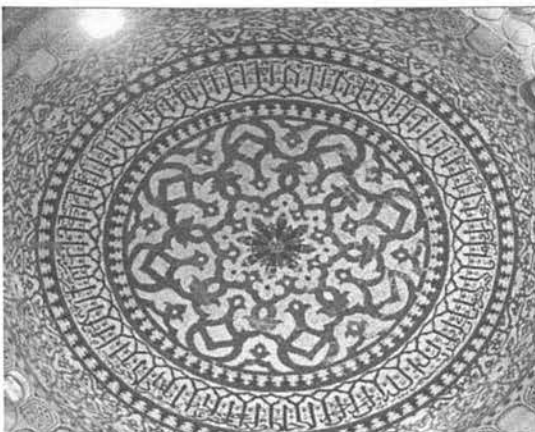


Fig. 2.49. Domes *Faraj Ibn-Barqūuqe* in Egypt



The most striking example of the spherical triangle and decoration is to be found in Ottoman period buildings in Turkey, such as in the great mosque of *Üluc-Jāmī* in Bursa, from 1399 AD; the complex of *Süleymaniye* from 1557 AD, and the Complex of *Sultan Ahmet* from 1616 AD in Istanbul (Fig. 2.50), the author has visited this place, in June, 2000. Another example can be found in Baghdad from the Ottoman period at the *al-Qumriyya* mosque from 1228 AD (Philon, 1991, p.247).

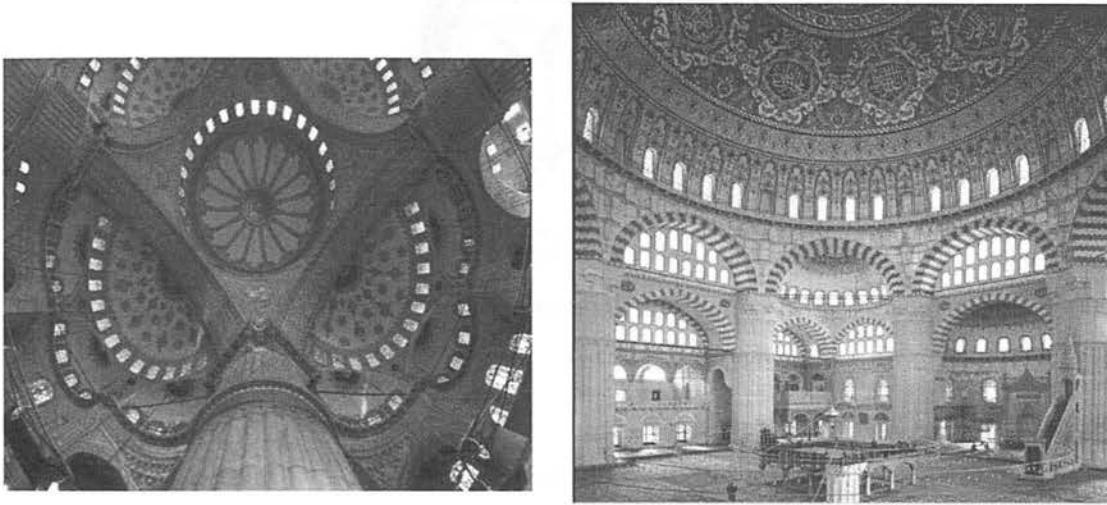


Fig. 2.50. Domes of Süleymaniye and Sultan Ahmet in Istanbul

**The second method:** The sphere angle corner method, called a 'squinch', "is a mini-arch which is used to bridge a diagonal corner area and its base at the top provides a platform for the dome" (Dictionary of Arch.net, Squinch, 2007). "It has a particular dihedral angle (the angle between two intersecting arcs on a sphere" (Spherical, 2007). In the construction of architecture, it is half of a semicircular recess in the corner, used in order to fill in the upper angles of a square room to hide the hard edges, and to support the form of niches of a right angle form of an octagonal and spherical dome. The squinch is a solution for the angle corner of a square room and the back of the arch of a domed room. The filling of this squinch unit may be split up into small units derived from the big unit, which is, in turn, filled by miniature



squinches, arising from the muqarnas inclusion at each of the corners, so imparting unity on the construction (Fig. 2.51).

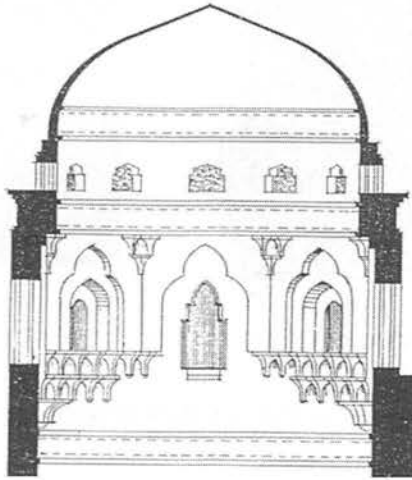
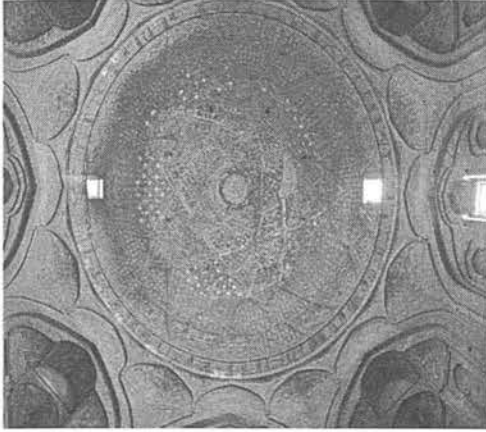
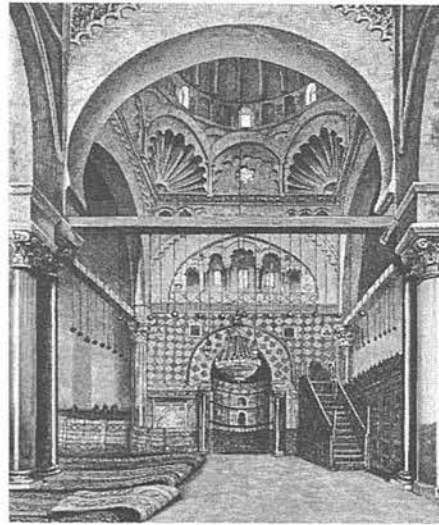


Fig. 2.51. The muqarnas in squinch at domed room

The earliest examples of the use of the squinch in Islamic architecture date to the early eleventh century, and can be found in the dome of the mihrab of the *Qairouan*, the great mosque in Tunisia, in AD 862 (Goodwin, 1991) (Fig. 2.52). An early example of the splitting up of the squinch of the dome into miniature squinches can be found in the portal of the dome in the great mosque of *Ardestan* in Iran from AD 1055, in the *Seljuq* period, where it has the form of a three-lobed arch in the corners, divided into niches and arches, separated by two pendentives. On top of each corner is a large niche containing a squinch over two arches, flanked by two arches, and crowned by a vaulted squinch and two pendentives (El-Bash, 1965). Also, "a similar splitting up of the squinch of the dome is found in the big and small domes of chambers in the great mosque of *Isfahan*, Iran from AD 1088" (Hutt, 1991, p. 253). Another example is in the dome of the Friday mosque of *Varamin* in Iran, from AD 1332–6 (Fig. 2.52).



The dome in Iran



The dome in Tunisia

Fig. 2.52. The dome of Friday mosque in Iran and the dome of *Qairouan* in Tunisia

Although Tabba emphasis the squinches of the muqarnas vaults were not confined to Persia but were used all over the Islamic world, in the Middle East, North Africa, India and Central Asia, and its greatest spread and innovation occurred between the twelfth and fifteenth centuries from Spain to India (Tabbaa, 2002, p.2).

An innovation of the corner recess of the muqarnas vault, achieved with trefoil arches, one on top of the other two niches, was found in the dome of the Great Mosque of *Isfahan*, Iran built in AD 1088. It appears, with similar divisions, in Fatimid buildings, such as the dome of *Al-Imam Muhammad Al-Jaafary* from AD 1120, the *Mashhad of Sayyida Ruqayya* built in AD 1133, the *Mashhad of Sayyida Atika* of AD 1125, and the Mausoleum of *Yahyā al-Shabīh* from AD 1150, in Egypt. Other examples of muqarnas vaults, with increasing numbers and repeating rows throughout the ages, can be found in the *madrassa* of *Sultan al-Salih Najm al-Din* built in AD 1250, in Egypt, in the Ayyubid period. Examples can also be found of muqarnas vaults in four rows, in the dome of the *khanqāh* of *Sultan Baybars al-Jashankīr* built in AD 1310, in Bahri from the Mamluk period. Furthermore, muqarnas vaults in nine rows can be

found in the dome of the *khanqāh* of *Sultan Faraj Ibn Barqūq* from AD 1401 (The author has visited this place, in October, 2002).

The next step in the development of the muqarnas vaults can be found in the dome of the *Imām Al-Shāfiʿī* mosque from AD 1211, in which there are three rows of small concave niches. The lower one contains a central squinch, flanked by two small concave niches, while the middle row consists of five rows of small concave niches, on and over each other, in which small niche-like components are combined with each other in successive layers, all of which are crowned by a main arch with two smaller arches.

The squinches of the *Imām Al-Shāfiʿī* mosque reveal a new stage in their bulging-out and deeply set brackets, which are arranged so as to overlap, with each row overlaid. This is based on a series of developments in the muqarnas vaults and semi-circular recesses in a corner, and paves the way for the next step in the development of the muqarnas vault, where stalactites were inserted and attached to the small sphere angle corner. Small niche-like components were combined with each other in successive layers, to enclose a space.

Other examples of muqarnas domes can be found in Egypt in the thirteenth century, for example, in the mausoleum of *Shajarat al-Durr* from AD 1250, which is a keel-arched squinch, flanked by two arched niches and crowned by an upper with three rows of small muqarnas. In the mausoleum of *Fatima Khatun* from AD 1284, there is a simple division of two small niches between upper and lower niches, while in *Zawiyat al-Abbar*, from AD 1285, there are three small niches crowned by three other small niches, and in the mausoleum of *Khalil*, built in AD 1288, there are three rows

of small niches containing, from the bottom up, five, three and one small niches (El-Bash, 1965). Another example of an unequal muqarnas dome which is crowned like a window by two rows and crowned by an upper with three rows of small muqarnas, can be found in the unequal two domes of the *khanqāh* of *Amir Sanjar al-Jawli* built in AD 1303, in Bahri, Egypt from the Mamluk period.

The muqarnas vault has been used in Syria since early times. In the *Nuri Maristan* from AD 1154, a dome covers the monumental room behind the first entrance. This dome rises over a pair of semi-domes covering the deep recesses in the north and south walls. Its muqarnas is plaster cast, moulded and attached to a wooden framework. A later dome in Damascus has, however, a real muqarnas vault, that is, the tomb chamber in the *madrasa* and mausoleum of *Nur al-din* dome from AD 1172 (Fig. 2.26). The oldest conserved style is *Imam Dur*, in AD 1085, and one may follow its development up to Damascus.

On the other hand, true stalactites appeared very early in Arab-Islamic architecture in the west of North Africa. They are found, for example, "in *Qal'a Bani Hamma* palace and tower, built in AD 1100, and in the mosques of *Kutubiyia* from AD 1153, from the *Almohad* period, in Marrakesh" (Michel, 1991, p.217).

Moreover, there are a very few examples of non Arabic-Islamic muqarnas in Europe. "One was built in southern Italy by the Norman king Roger II, who in the mid twelfth century ruled in Sicily (Italy) only just conquered from the Muslims. His throne hall, now the Capella Palatina in Palermo, displays a splendid wooden muqarnas ceiling" (Michel, 1991, p.222). The other example is in the United Kingdom in Glamorgan, Wales, in the Arab Room in the Herbert Tower (1876–1886) in Cardiff Castle (was visited by the author in April, 2005.) (Fig. 2.53).

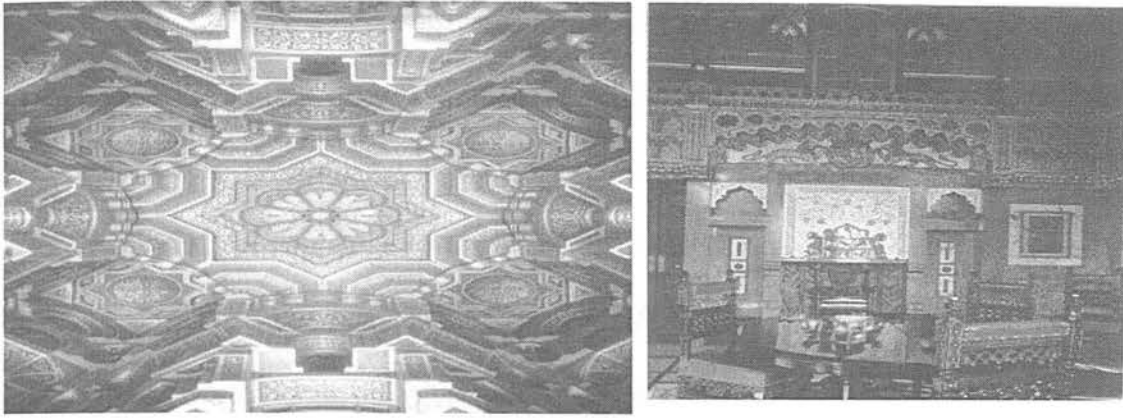


Fig.2.53. The Arab Room in the Herbert Tower in Cardiff Castle

#### 2.7.4. Implementing of the muqarnas in minarets

'Minarets are distinctive architectural features of Islamic mosques' (Naser, 2009, p.128), and they are higher than the main building by several floors, and are decorated elegantly and in layers of grids organised by the various rows of muqarnas. In addition, a minaret is used by the *muezzin*<sup>x</sup> for the *ad'han*<sup>xi</sup> to call people to prayer. They The ground floor of a minaret is always fitted into a square, with the higher parts of the minaret being anything from square to round – many are even octagonal. On top, there is a tiny room for either the muezzin or the loudspeakers (Kjeilen, 1994). The idea of the minaret is related to the observation or sacred towers, such as can be found in India and Middle Eastern lands. Creswell traces its origins to its use by Jews as a horn (*shofār*) and by Christians as a *nāqūs* or clapper (Creswell, 1989, p. 5), and as a minaret it has become synonymous with Islam.

In earlier Islamic architecture, the old Arabic word "*Sawma'a*", which was derived from the English *silo* refers to the minaret" (Lamie, 1984, p. 30), which was constructed by building a rectangular shaft on a square geometrical shape; it stood tall on slender square tower projections. The square tower style was formed based on

traditional Syrian minaret style, such as those that could be found in ascetics' towers in Syria (Salim, 1991), and consisted of a square-plan tower built of stone. The form is thought to have derived from the traditional Syrian church tower of the Byzantine period (Creswell, 1989). Then it became the first style of minaret tower in Islamic architecture and subsequently spread throughout the Middle East, North Africa and Spain. The square tower style and the word *Sawma'a* (silo) are still "in use in Morocco and North Africa today" (Salim, 1991, p.3).

The first square tower minarets in the Islamic era were designed for the corner of the mosque of *Amr Ibn al-Ās* at Fustāt, in the Abbasid period, in AD 641, and were built of bricks with square towers, in the sacred tower beside the courtyard of the mosque. Other examples of square tower minarets in the Muslim world are evidenced by rulers of North Africa who marked their territory by building great square minarets like the one of the *Qairouan*, the great mosque in Tunisia built in AD 695, and the square minarets of the *al-Hambrā* palace, built in the thirteenth and fourteenth centuries in Granada in Spain (Abdulgawad, 1970) (Fig. 2.54).



Fig. 2.54. Minarets of the Qairouan mosque and the al-Hambrā palace.

Other admirable examples of minarets carved in stone can be found in Egypt, and can be described as important references and a source of the various styles in Islamic architecture, such as in post-Fatimid Egypt, where minarets were developed into complex and distinctive forms. Each tower is composed of three distinct zones: a square section at the bottom, an octagonal middle section and a small dome on the top, the transition zone of each section is decorated with a group of muqarnas; the unique spiral minaret in the mosque of *Ahmad Ibn Tūlūn* from AD 867–79, in Cairo, recalls the original Iraqi type. An example of the Samarra style from AD 847, it rises out of the courtyard of the mosque, with an outer staircase, and a compound that consists of three geometric shapes: i) a cylindrical-body fitted into a square; ii) standing tall on an octagonal, with its ribbed helmet on top, and iii) the muqarnas with two rows on the top of the ribbed helmet, as decorated, over each other, in successive layers, making harmonious proportions in relation to the height and the whole of the minaret (Fig. 2.55), the author has visited this place, in February, 2002.

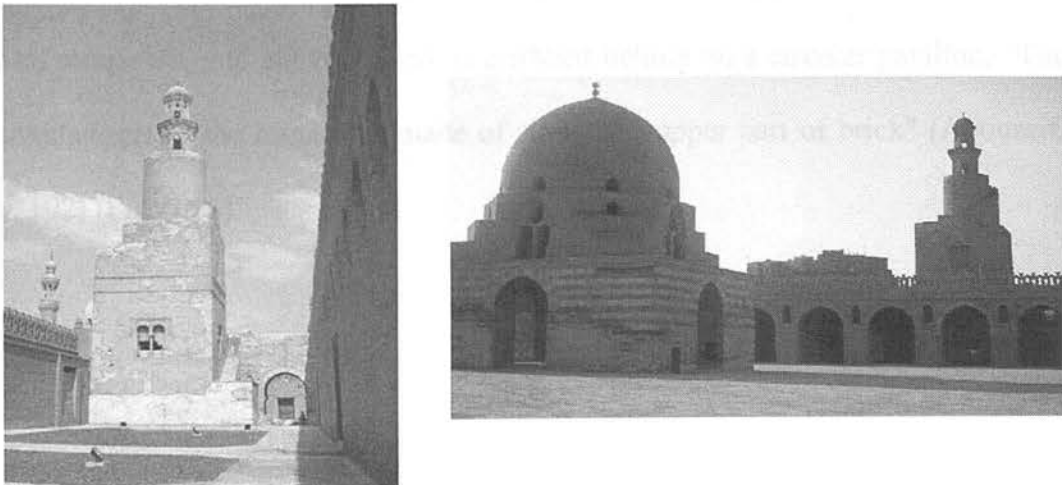


Fig. 2.55. The mosque of Ahmad Ibn Tūlūn in Cairo.

Other examples of minarets with muqarnas as an architectonic form include a muqarnas resembling corbels supporting a balcony on the top part of the minarets



instead of the wooden corbel which was widespread in the architecture of *the Bahri Mamluks* (Lamie, 1984). The most remarkable minaret example is that of Sultan *al-Nāṣir Muhammad Ibn Qalāwūn*, built in AD 1295/6–1303 in Cairo, which consists of three rows of muqarnas as a corbel supporting a balcony on the top of the lower part. The ground floor of the minaret is fitted into a square, with the muqarnas under the surface of the horseshoe arch and windows. The second storey of the minaret is octagonal in section with a keel-arch panel on each side, formed by a moulding running around the whole, flanked by two rows of muqarnas. The third storey on top of the shaft of the minaret is heavy, with bunches of muqarnas "hanging like grapes" (Abouseif, 1989, p. 100). Their shape, like that of the *Madrassa of Amir Sanjar al-Jawlī*, built in AD 1303, in Cairo, shows each side having an arched panel resting on four rows of muqarnas on top of the square parts of the minaret, and flanked with colonnades, the horseshoe arch and double window with a bull's-eye.

The other muqarnas are on top of the middle and upper parts of the minaret, where the upper structure is slender; the octagonal elongated section supports a cornice of four rows of muqarnas, and above it there is a ribbed helmet on a circular pavilion. "The rectangular part of the minaret is made of stone, the upper part of brick" (Abouseif, 1989, 102) (Fig. 2.56).



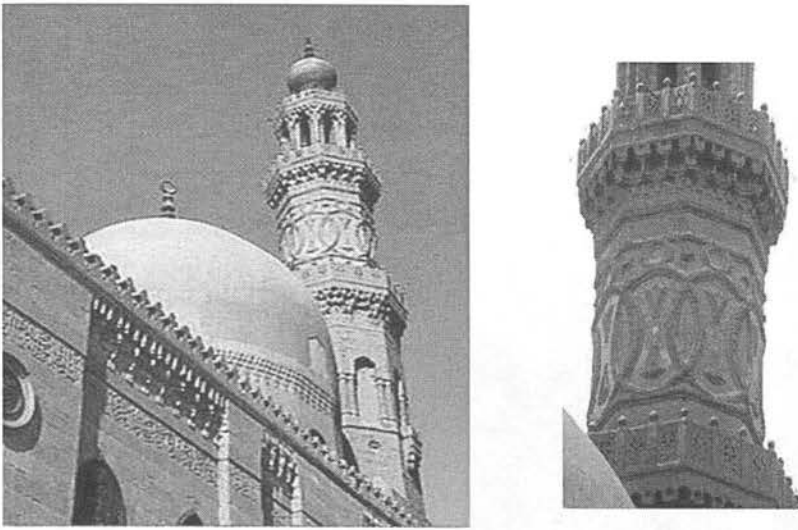


Fig. 2.56. Sultan al-Nāṣir Muhammad Ibn Qalāwūn, in Cairo

Another marvellous and most beautiful example of a minaret can be found in the mosque of *Sultan Hassan*, built in AD 1356, in Cairo, which is an example of a development in the style of minarets. The three rows of the muqarnas in the upper part are fitted into the square in the first part, and each fragment of stone is resting on four rows of muqarnas on top of the higher part, fitting into an octagon in the second part. The shaft and balcony on the minaret, and the upper part, are flanked by eight colonnades and helmets with circular upper parts and with two rows of muqarnas and a crescent on the top, creating a harmonious and proportional style (Fig. 2.57), the author has visited this place, in February, 2002. That style of minaret of the *Circassian Mamluk* period continued to the end of the *Bahri Mamluk* period, but in the middle of this era, "the minaret was fitted into a circular projection and there was an increase in the rows of muqarnas" (Lamie, 1984, p.32).



Fig. 2.57. The mosque of *Sultan Hassan*, in Cairo

The most beautiful example from that period can be found in the minaret of the *kanqāh* of *Sultan Faraj Ibn Barqūq* in Cairo from AD 1411, where there are two rows of muqarnas on top of the lower part that begin as rectangles, with an arch panel on each side, formed by two rows of muqarnas around the whole flank. The second storey is receding and circular, and there is no transition between the two storeys. The middle of the shaft is carved with intersecting lines and there are four rows of muqarnas on the second part of the minaret in the section between the shaft and the balcony. The upper part is flanked by eight colonnades and helmets with a circular upper part of two rows of muqarnas. The upper part of these minarets is composed of two distinct zones: an octagonal section and a circular section with a dome on the top, "which is similar to a few of the *olla* (jar) or pear shapes, and this became known as the olla style" (Shafie, 1970, p.165) (Fig. 2.58), the author has visited this place, in February, 2002.

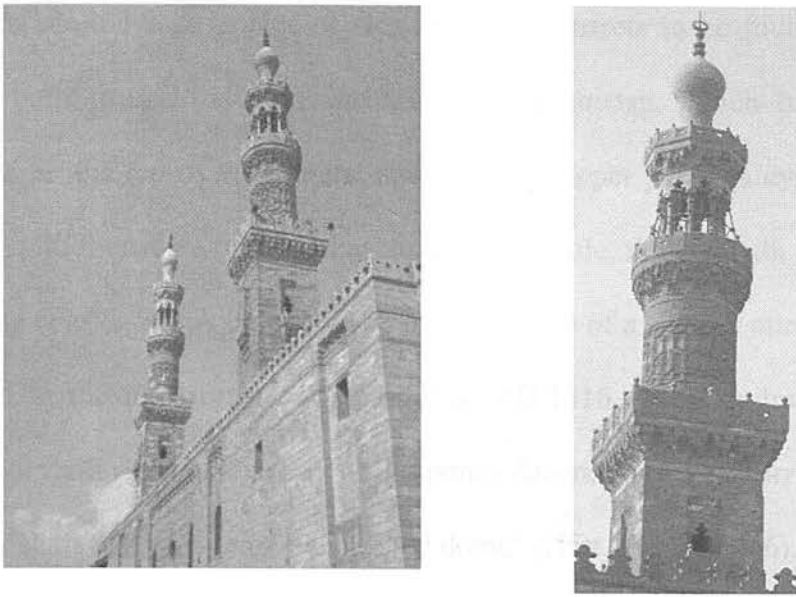


Fig. 2.58. The Sultan Faraj Ibn Barqūq in Cairo

The form of the minarets and the rows of muqarnas are dissimilar throughout the Islamic world. For example, in central Asia, Iraq and Iran, they continued to evolve with a round shape or slender minarets, and they became larger and higher. The top of minaret were covered with band of decorated muqarnas reached on the crown of shaft and under the balconies of the minaret. An old example of this minaret can be found in the *Kirat* minaret, in Iran, from the eleventh century, which has a high octagonal base, which originally supported a balcony which was entered from the cylindrical shaft. The balcony was supported on corbelled brick columns with muqarnas vaulting, strengthened by wooden beams. Another example is in the tomb tower of the *Gunbad-I-Qābūs*, built in AD 1007, in Iran, which is "a great Seljuk building of the late eleventh century in Central Asia. It is an octagonal tower with a perfect conical roof" (Hutt, 1991, p. 253). It is ornamented with a corbel frame supporting a roof, and two rows of pendentive-style muqarnas, and was used for the decoration of the portals, and to support the half-dome above the minarets (Fig. 2.59).

There are admirable examples of slender brick minarets to be found in the *Kalyān* mosque built in AD 1514, in *Bukhara* in Afghanistan, which has two rows of muqarnas on the top of the minaret shaft and the upper part is a cylindrical form of balcony, with four rows of muqarnas around the whole, flanked with a circular helmet on the top (Fig. 2.59). A unique decorative example of a slender minaret in brick can be found in the minaret of *al-Kifl* built in AD 1316 (24m) in Iraq, which has "a cylindrical shaft and double rows of muqarnas decoration which carry a gallery and a narrower shaft that is covered by a ribbed dome" (Hutt, 1991, p. 246).

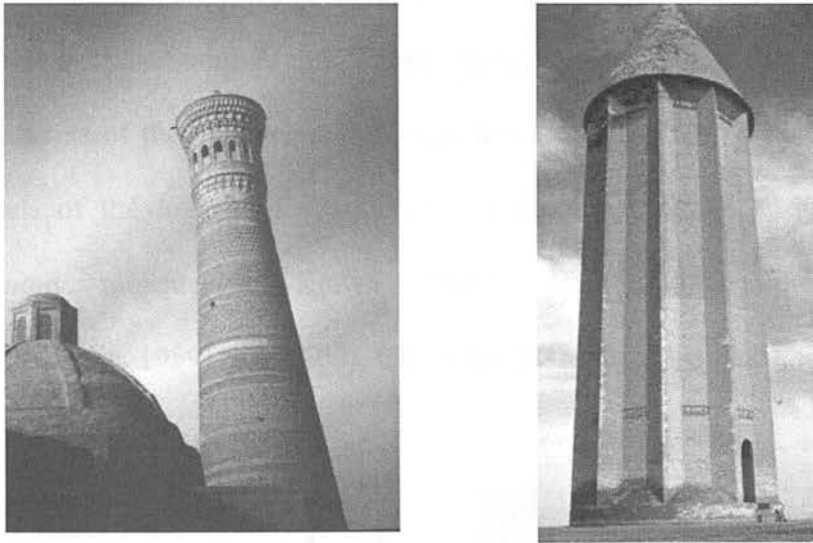


Fig. 2.59. The Kalyān mosque in Bukhara and Gunbad-I-Qābūs in Iran

In the same tradition are the designs of the minarets of the Seljuq period, which have a slim cylindrical tower form and balcony tier. The exteriors are often covered with ornamented tile-work decorated by muqarnas around the balcony and windows. An old example of this feature of the minarets from the Seljuq period can be found in the *Döner Kūmbet*, built in AD 1276, in Kayseri in Turkey, which is raised over a burial vault within a stone base, and is divided into a panel which is itself divided by ribs and arches which recur on the conical roof. At the top, geometric designs lead into the

shallow muqarnas cornice under the roof. However, the minarets from the Ottoman period are the same versions of Seljuk minarets. Although Ottoman architecture, they seem to have developed from the local school or style, characterised by its independence from foreign influences.

Ottoman minarets are characterised by their slim cylindrical shape and are decorated by muqarnas around their balconies. However, the Ottoman designers and artisans developed the number of minarets on mosques, using four and six minarets in one mosque, which became a popular style in Ottoman buildings, and was used primarily in Ottoman mosques built in Turkey and the Middle East in countries such as Saudi Arabia, Egypt, Syria and Iraq. Examples can be found in the minarets of the *Süleymaniye* mosque built in AD 1550–7 in Istanbul, and the minarets of the *Sultan Ahmet* mosque in Istanbul, from AD 1609, and in the *süleymany* mosque in Konya, Turkey from the seventeenth century (Abdulwahabe, 1959) (Fig. 2.60), the author has visited this place, in June, 2005.

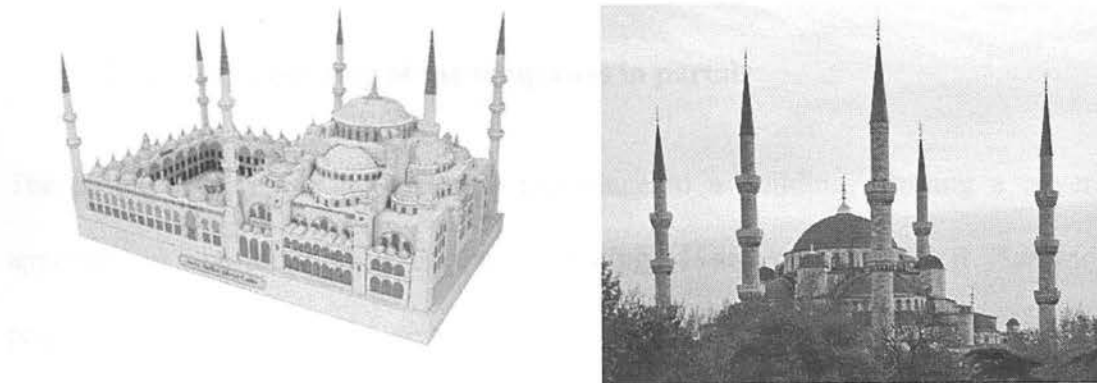


Fig. 2.60. The Sultan Ahmet mosque in Istanbul.

Other examples as noted by the author can be found in the minarets of the Holy mosque in Makkah and in the minarets of the mosque of the Prophet in Medina, in Saudi Arabia, which was built in the Ottoman period in AD 1627 (Fig. 2.61). The

muqarnas in these examples have become corbel-supporting and decorative around the balconies of minarets, which are presented in a rhythmic arrangement of lines and arches, with three rows of muqarnas. The muqarnas plans are in geometric formation and represent a pure beauty, in harmony with the aesthetic proportionality of all the components in the minaret building, which presents to the viewer a great relationship in terms of the link between muqarnas and minarets.

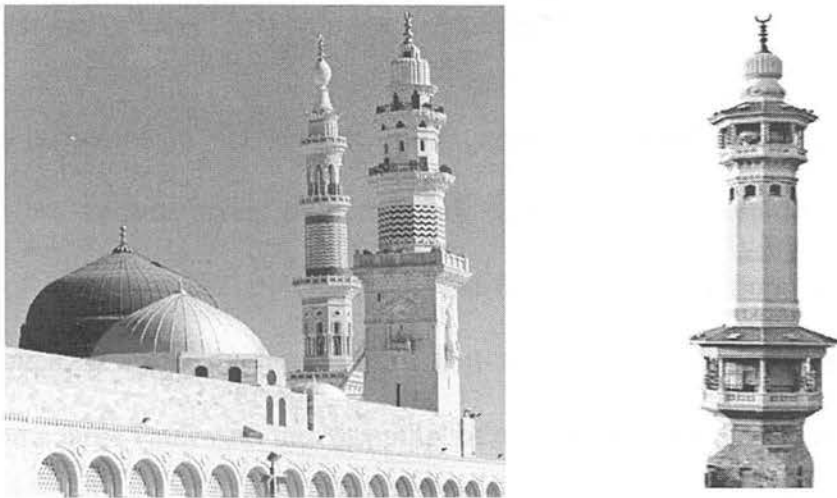


Fig. 2.61. The minarets of the Holy mosque in Makkah and in Medina.

### 2.7.5. Implementing of the muqarnas in portals

The portal or porch is "an exterior appendage to a building, forming a covered approach or vestibule to a doorway" (Ching, 1996, p.382), and it "luxurious proportion higher than the rest over a doorway at the entrance to a building" (Abouseif, 1989, p. 138). More interesting aspects of portals are their construction and their decoration. The decoration of the portals gives the same impression of a porch, or a walkway having a roof supported by columns and domes. Also, they create a visual transition between covered entrances to a doorway.

Muslim architects were keen to redecorate entrances by using muqarnas, and by introducing certain innovative Islamic vaulting techniques, especially the elaboration of squinches and cross vaults, which they found in several parts of the Islamic world, and they became one of the characteristics of Islamic architecture. For instance, in 11<sup>th</sup> century Cairo, 14<sup>th</sup> century Granada or 16<sup>th</sup>-19<sup>th</sup> century Turkey, the portals were built with an unusual number of different techniques of vaulting and muqarnas. Squinches coexist with pendentives, barrel vaults with cross vaults, a simple semicircular arch with pointed or horseshoe arches.

The portal is dominated by a cascade of muqarnas surmounted by a fluted half-dome, and there are various styles of portals, all of which depend on the architectural tradition of its location. They can be carved in deep relief in floral and geometric patterns, such as a rectangular recess, trefoil-arch, groin vaults, trilobite and conch recesses on a large vault with the 'dripping' of muqarnas above the entrance bay, such as what is created muqarnas concave composite, or muqarnas prismatic composite, or stalactites, that have been lavishly used as decoration in the deep hoods over the portals, and they became highly ornamented, for example, there can be a band of carved wood or stone inlaid with marble and coloured stones can frame the doorway, but normally, they are made out of masonry and adorned with pillars.

Creswell (1989), has demonstrated that the portals of the muqarnas can trace their origins to Syria, where there are examples that are earlier than those in Egypt, and he considered them one of the most important elements which played a large part in the constructions and decorations of doorways in the Mamluk period of architecture. Perhaps, the portals were used in Syria about a century before they were in use in Egypt, such as those designed in the gateway of the palace of *al-Mu'tasim* (*Jawsaq al-*



*Khāqānī*), known as the *Bāb al-ʿĀmma*, built in 836 AD, in *Sāmarrā*, during the Abbasid period, "which was covered by a semi-dome on squinches with a door leading to the rear barrel-vaulted chamber, giving access through a rear door to six transverse halls" (Philon, 1991, p. 250) (Fig. 2.62).



Fig. 2.62. Portals of Jawsaq al-Khāqānī, in *Sāmarrā*, in Iraq.

"The Syrian portals are plain and simple without the use of any decoration, nor are they adorned by architectural elements, like the Egyptian portals" (Creswell, 1989, p. 40). Examples of Syrian portals can be found in the *Great Mosque* in Damascus, built in AD 709–15, from the Umayyad period; in the *Great Mosque* in Aleppo, built in the eleventh to thirteenth centuries, in Seljuq during the Mamlūk period; in the *al-Firdawsī* Madrasa, in Aleppo, in AD 1234–47, in the *Ayyūbid* period; in the mosque of *Dervish Paşa* in Damascus, in AD 1574; and in the *Khān al-Wazīr* in Aleppo, in the seventeenth century, during the Ottoman period (Warren, 1991, p. 233).

The decoration in the portals was created by carving small muqarnas, creating a transition between the covered entrances to a doorway without a screen wall. In the fourteenth century, the trilobite portal developed from a plain conch to more intricate variations on the same theme, with mouldings and carvings framing the trilobite arch, carvings adorning the conch, pendentives used underneath the muqarnas, and the use



of various types of muqarnas in different proportions. In the fifteenth century, there was a new type of portal treatment, where its interior was carved with groin vaults in the shape of a half-star. Sometimes the niches formed by the intersecting groin vaults were filled with muqarnas, and often the conch was adorned with an inlaid console (Ablaq)<sup>xii</sup> or corbel with parallel sides.

A fine example of portals created with muqarnas is found in the entry of the *Madrassa of Iljāy al-Yūsufī* built in AD 1297, in Cairo. Its interior has three to four rows of Shami muqarnas in the upper part of the doorway at the entrance. Other magnificent vaults of this type can be found in the *Khān al-Khalīlī* at the portal of Sultan *al-Ghūrī*, built in AD 1503. Also in the portal of the palace of *Amir Qūṣūn* (palace of *Yashbak*) built in AD 1337, in Cairo, which has six rows of Shami muqarnas in the squinches of the two domes (Fig. 2.63), the author has visited this place, in February, 2002.

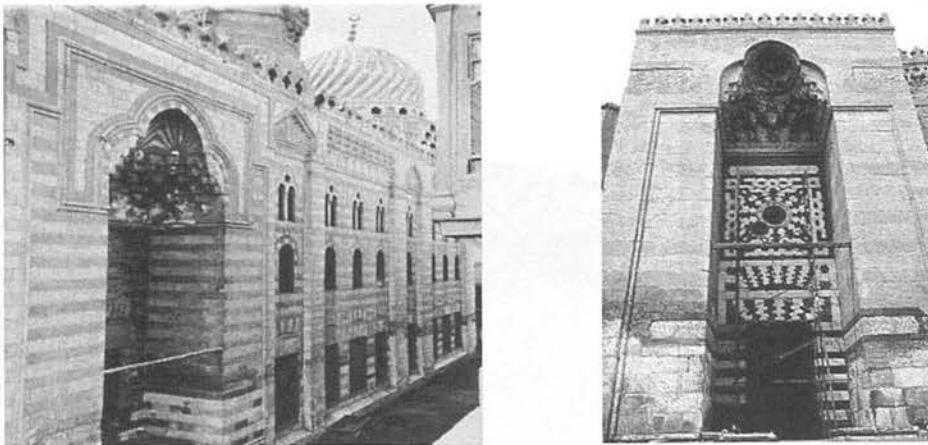


Fig. 2.63. The Madrasa of Iljāy al-Yūsufī and Khān al-Khalīlī in Cairo.

The architecture of the portal of the muqarnas became "a significant part of the façade, and a most remarkable feature in Islamic architecture" (Abouseif, 1989, p.124). The inner portals are composed around an arch framed with interlacing bands of black and white marble console (ablaq), which are enhanced by a *mastaba* (stone

bench), as they were known in the Ottoman period, or a wall above the entrance, flanking the windows. The panels are filled with geometric patterns, with stone inlaid with marble and a coloured frame over the doorway. The muqarnas portal is composed of a semi-dome resting on muqarnas.

An early example of this feature of a muqarnas portal can be found in the portal of the mosque of *Amir Bashtāk*, built in AD 1336, in Cairo, which has "a rectangular recess with dripping muqarnas stalactites above the entrance bay (Abouseif, 1989, p. 16). Another striking example can be found in the mosque of *Sultan Hasan*, built in AD 1356, which occupies the whole length of the façade, making it by far the largest in Cairo. "It is dominated by a cascade of dripping stalactites surmounted by a fluted half-dome. Also, the architecture of *Sultan Hasan* portal has been influenced by *Saljūq* architecture" (Abouseif, 1989, p. 124) (Fig. 2.64), the author has visited this place, in February, 2002.

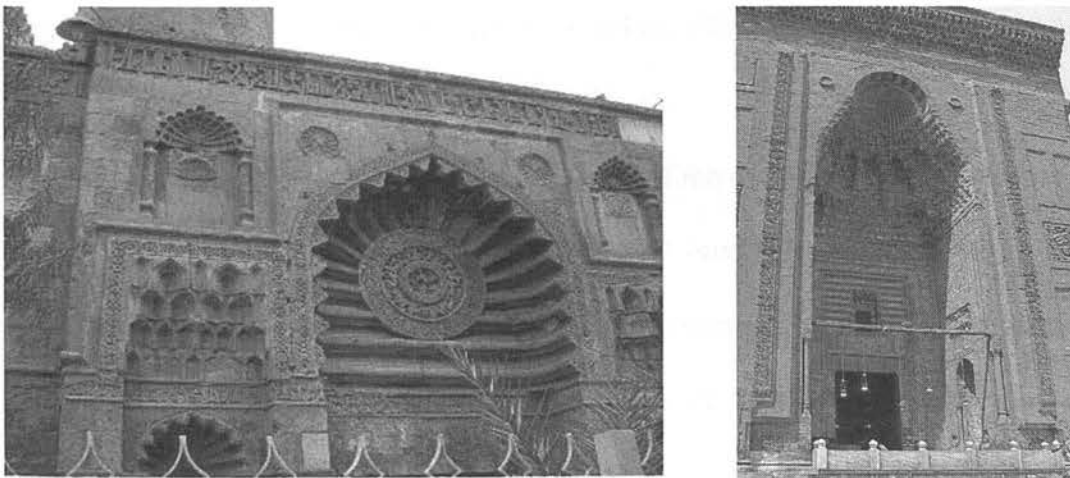


Fig. 2.64. The mosque of Amir Bashtāk and Sultan Hasan portal in Cairo

The earliest extant muqarnas on a façade portal decoration in Egypt dates to the Fatimid period, during the mid twelfth century; it can be found in a portal of the *al-Aqmar* mosque, built in AD 1125 in Cairo, where it is used in the centre of the façade.

"It has a large keel arch niche, and on both sides of the main niche, there are smaller niches, also with fluted hoods, which are surmounted with recesses crowned with muqarnas" (El-Basha, 1965, pp.34-37). Other examples can be found in the portal of the *khanqāh* of *Baybars al-Jashankir*, in AD 1307, and the portal of the mosque of *Amir Bashtak*, built in AD 1336, and the portal of the mosque of *Amir Alinbugha al-Maridani*, from AD 1340.

There is also an early association with a portal that was used as a cornice decorating the exterior of a tomb tower and with ornamentation on the interior. As such, the muqarnas "played an important part in Persian entrances in Iran and Iraq" (El-Basha, 1965, p.34). The oldest example can be found in the portal of the tomb tower of the *Gunbad-I Qābūs*, built in AD 1007, in Iran in central Asia (Fig. 2.59), which has a cylindrical tower with a perfect conical roof in the helmet; the exterior is ornamented with ten-angle corbels, "which merge with the base angle line and the corbelled rim that supports the roof, and three of the muqarnas are 'dripping' in the pendentives supporting the half-dome above the entrance" (Hutt, 1991, p. 253).

Other examples can be found in Iran in the portal of the mausoleum of the *Jenbad Ali*, built in AD 1056, in *Abar-qooh-ran*, and *Masjid-I-Jami* (Mosque), located in Yazd, which was mainly constructed during the fourteenth century. It has eight ribs with five rows of groups of muqarnas on the whole portal, each group having eight groups of overlapping muqarnas. The other example of the portal of the *Masjid-I-Jami* in Isfahan, in AD 1072–92, "shows the elaboration of squinches and cross vaults in the roof and ceiling of the entrance" (Hutt, 1991, p. 253) (Fig. 2.65).

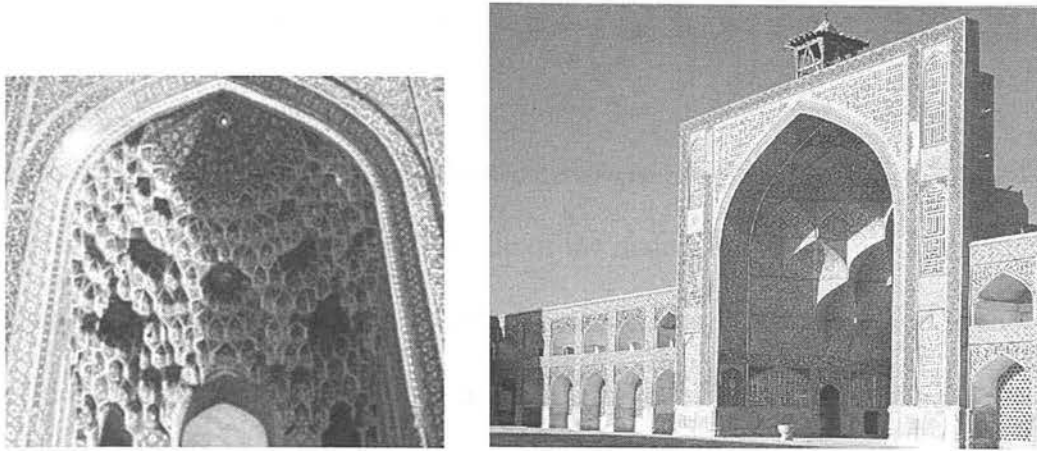


Fig. 2.65. The portal of Masjed-I-Jami in Yazd, and in Isfahan, in Iran.

### 2.7.6. Implementing of the muqarnas in façades

A façade has been known is exterior face of a building or a wall, and showing any one side, exterior or interior of that building,

The term implies ordered placement of its openings and other features and thus seems inapplicable to a wall without design; a building flanked by other buildings on either side generally has only a front and a rear facade. (Columbia Electronic Encyclopedia, 2007).

The Islamic architectural value concerns the adjustment of the front and sides of a building to give it a final technical finish, by adding beauty of architecture and art of design to the surfaces. It is usually enhanced by elaborating some architectural or ornamental details. Therefore, the front wall, and the exterior and interior of the building are designed using different techniques of muqarnas vaulting. The muqarnas in the elevation of a building can be divided into three kinds: The first one is the recessed panel of the muqarnas that finishes with a number of tiers and a number of windows. The second is the cornice of the muqarnas that used in the decoration and in the shelving cornice. The last one is the corbel of the muqarnas, which corbel frame that supports a horizontal part or any weight on the wall, as follows:

### 2.7.6.1. Implementing of the muqarnas in recessed panels

The architects divided the vertical surfaces in recessed panels of the elevation of a building in Islamic architecture into: middle of the main divisions of the fenestration drape, inside wall of the façade as a vertical recess between architrave and shelving cornice decorated by muqarnas above, and also, sometimes they are decorated with two to three, sunk vertical windows (*chemmassiat*<sup>xiii</sup>) in the middle and separated by a column. The purpose of these apertures is to admit light and to let fresh air come into the heart of the building, thus preserving the coolness; and to support a horizontal member which carries the weight of the wall above it.

The recess panel style of muqarnas usually contains decoration with covers the walls between various horizontal and vertical surfaces, and continuous carved surfaces. The principal is leading the eye moving from one surface to another and serving to give a linear emphasis to used carved ship into view. The construction of recessed panels of muqarnas can be such are in lines side-by-side, cornice and corbel, in which the small moulded concave niche components are combined with each other in successive layers, to produce surfaces made skilfully to reveal the richness of the decoration of the muqarnas.

The technique and shapes of the recess panels and the tier windows (*chemmassiat*), which are between the architrave and cornice, depend on the forms of the arches that enclose them. Thus forms might be finished with numbers of muqarnas in tiers or rows and in several sizes and two- and three-dimensional forms and they were often filled by figures in relief.

The variety of materials and techniques used in the decoration of the recess panels of the muqarnas is very impressive in terms of Muslim craftsmen's expertise. Sometimes the decorative effect was achieved by putting the muqarnas together where small stones had been cut into various geometrical shapes. Infrequently, two or more different kinds of stone were used in order to obtain a coloured effect. Stucco reliefs on back wall recess panels of muqarnas were common in Islamic architecture, and another technique favoured by Islamic masons and artists was the geometric inlay of glazed terracotta.

The author has considered there are different types of the recess panels of muqarnas, as follows:

- A. The recess panel consists of the keel arch in the form of the triangle arch (Baladi type) (Fig. 2.66- A).

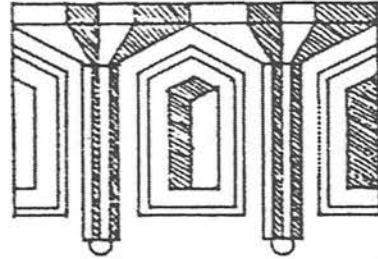


Fig. 2.66- A

- B. The recess panel consists of the pointed arch in the form of the semicircle arch (Shami type) (Fig. 2.66- B).

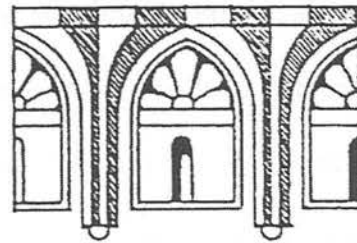


Fig. 2.66- B

- C. The recess panel consists of a pointed arch and a keel arch, ornamented by epigraphs or vegetation (Baladi and Shami types) (Fig. 2.66- C).

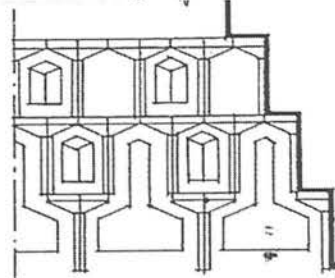


Fig. 2.66- C

- D. The recess panel consists of a keel arch in the form of cascade tail (stalactite type) (Fig. 2.66- D).

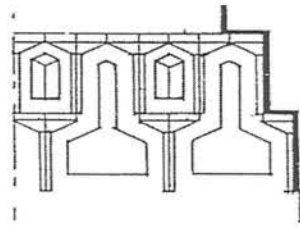


Fig. 2.66- D

- E. The recess panel consists of a pointed arch in the form of cascade tail (stalactite type) (Fig. 2.66- E).

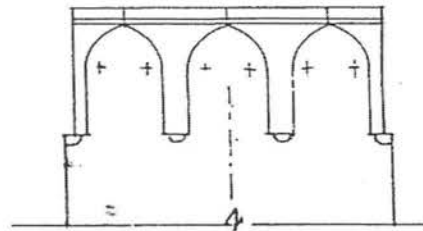


Fig. 2.66- E

The idea of the architect dividing the vertical surfaces in the recess panels in the elevation of a building existed before Islam, and we have evidence from the different views and appearances, in the long horizontal area between the architrave and cornice from Classical architecture. The earliest example can be found in the palaces of the the *Behram*, '*Bahram V*' in *Srvstan* from 420-438 A.D. (Creswell 1989, p. 105), and also in the *Shirin* Palace 591-628 AD (Janson, 1962, p. 81). it also can be found in many examples of Byzantine architecture from the Sasanian period (Shafie, 1970, p. 141). Another example was established in Greek temples with the decorated pediment "at the gable end of a pitched roof by the sloping eaves and a horizontal cornice" (Osborne, 1970, p.824), and can be found in the classic example of the Parthenon from 447-433 B.C in Athens. The other example can be found in the Byzantine architecture example of Hagia Sophia built in 537 B.C. in Istanbul.

The recess panels of muqarnas have become identical in Islamic architecture and decorative as piece of art, in many region of Islamic world, such as Iran, East Africa, Arabian regions and much of the Far East. This recess panel of the elevation of buildings has represented new distinctive identities. The oldest example of this is a



recess panel in the elevation of a building from the early Abbasid period, "which is the craftsmen used molding on recess panels, as the same as used in Sasanian architecture" (Shafie, 1970, p. 142). The oldest Islamic models appeared on the wall of the 'Ukhaydir Palace, from the Abbasid period, 777 A.D (Al-Any, 1983, p. 129) (Fig. 2.15), on the elevation of the gates of the Circular City in Baghdad, Iraq.

The finest examples in Iran can be found in the recess panel of the muqarnas in the tomb tower of *Gunbad-I QĀBŪS* built in 1007 A.D, it is over 51m high, and the corbelled rim supports the roof, and the two small muqarnas support the half dome above the entrance. Another example can be found in the palace of *Ālī Qapu*, from the *Safavid* period, early 17<sup>th</sup> century, in Isfahan (Fig. 2.67).



Fig. 2.67. The palace of Ālī Qapu in Isfahan.

In Egypt, the earliest recess panel of the muqarnas can be found in *Omer Ibn al-As*, built in AD 827 in Cairo. Another example can be found in the *al-Aqmaer* mosque, built in AD 1125 also in Cairo, which is a unique recess panel with lavish muqarnas decoration on the façade. Yet another example can be found on the recess panel of the muqarnas in the façade of the mausoleum of *Sultan al-Mansūāur Qalāwūn*, built in AD 1284 in Cairo, which has recess panels which include three tiers of windows, and a small row of muqarnas in the wall underneath the minaret. Another example can be



found in the *Zāwiya of Shaykh Zaun al-Dīn Yūsuf*, built in AD 1298–1325 in Cairo, which includes one level of windows within a trilobite-arched recess, framed in the upper part by a moulding and crowned with muqarnas. A further example can be found in the two windows above the entrances in the north-western wall of the mosque of *Sultan al-nāṣir Muhammed*, built in AD 1318 in Cairo.

A magnificent example of the recess panel of muqarnas exists can be found in the numerous elevation of a building of Morocco (Fig. 2.68), the author has visited this place, in March, 1995.

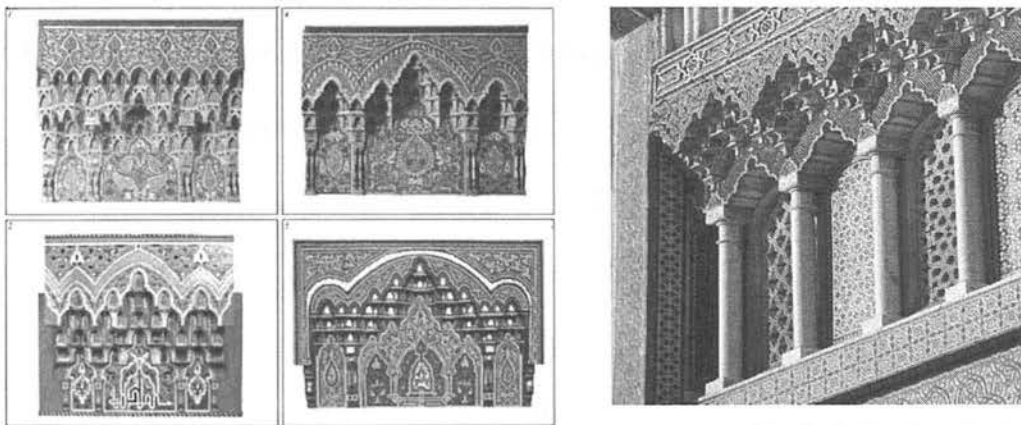


Fig. 2.68. The recess panel of muqarnas, in Morocco

#### 2.7.6.2. Implementing of the muqarnas in cornices

The muqarnas cornice in ornamental moulding is a projected decorative feature along the top of a wall or "arch or at the juncture of the walls and ceiling of a room" (Osborne, 1970, p. 282). Usually, the artisan used wood or a plaster material. In Islamic decorative styles they are distinguished by cornices of muqarnas forms that are used to convey an effect that is appropriate to the purpose of the building (Harris, 2005).

Cornices are very important to Islamic architects, and come in many types and shapes, especially those that are related to the cornices of vaulted muqarnas and where it is more harmonic with the design of the building. The author considers that there are different types of muqarnas cornices (Fig. 2.69), as follows:

- A. The cornice consists of one row of muqarnas,  
*Baladi* type or *Shami* type – (Fig. 2.69 – A).

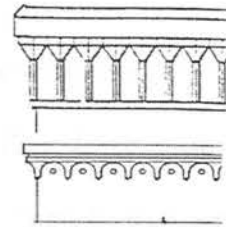


Fig. 2. 69 – A

- B. The cornice consists of two rows of muqarnas,  
a concave composite type, a prismatic  
composite type or a stalactite type (Fig. 2.69 –  
B).

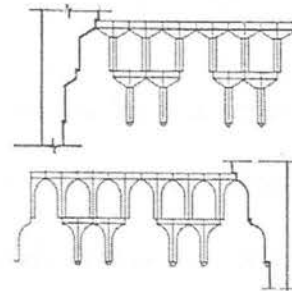


Fig. 2. 69 – B

- C. The cornice consists of three rows of  
muqarnas, a concave composite type, a  
prismatic composite type or a stalactite type  
(Fig. 2.69 – C).

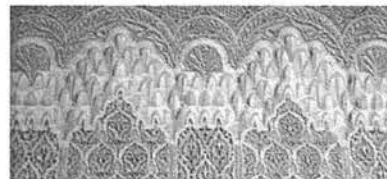
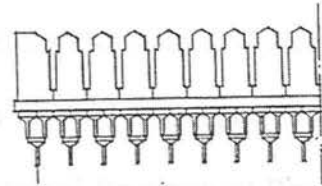


Fig. 2. 69 – C

### 2.7.6.3. Implementing of the muqarnas in the cantilever

A cantilever has been known is a beam or girder truss, and is a structural member or surface that projects horizontally beyond its vertical support, such as a wall or

column, and also, a projecting bracket is used for carrying the cornice or extended level of a building (Harris, 2005). In Islamic architecture and art, the cantilever of muqarnas is used to carry any support projections of the above. It was used in external buildings such as, under the shaft of minarets, on a doorway at the entrance, on the windows' head of an elevation of a building, and on the panels. Inside a building, it was used in the angle piers of the corner for a decorative overlay of the rectangular building, to support a projecting wall or parapet; and also, they were used extensively as above and between doors, windows, or other openings. They have appeared in towers, castles, fortresses and any traditional public building since Roman times, in the fifth and the sixth centuries, then widespread use into Islamic architecture.

An early example of this cantilever muqarnas can be found in the *Qasr al-Hayr ash-Sarqī* (East) Palace, built in 727-9 AD, in Syria from the Umayyad period, where "it is used to support a projecting parapet" (Creswell, 1989, p.209). It was also found in "the *Ukhaydir Palace* 777 A.D, in Iraq" (Creswell, 1989, p.128). It became popular and then it moved to different parts of the Islamic world, in western and eastern countries. A magnificent example of a cantilever exists on the wall of the gate of San Juan, built in 930 A.D. in Cordoba in Spain, which is borrowed from typical Roman cantilever stone, with two tiers of stalactite muqarnas. Another example of cantilever muqarnas can be found in post-Fatimid Egypt in *Bāb al-futūh* (gat) of *badr al-Jamālī*, built in 1087 A.D. in Cairo, which are on the lower part of the balcony and above the wall gate with a quality stone treatment.

Another example of cantilever muqarnas in wood, can be found in the *al-Aqmae* mosque, built in 1125 AD, in Cairo. Another example can be found in the *Madrassa* of *Sulatan al-Sālih Najm al-Dīn Ayūb*, built in 1243 AD, in Cairo, in the Ayyubid period,

and also, in the complex of *Sulatan al-Ashraf Qāyṭbāy* built in 1472-74 A.D. in Cairo, where the cantilever muqarnas has three rows of *baladi* type muqarnas. Other examples can be found from the Mamluke period in the mosque of *Sulatanal-Nāṣir Muhammad at the Citadel*, built in 1318-35 AD in Cairo, which is on the lower part of the minaret balcony. Finally example can be found on the minaret of the madrasa of *Amir Sanjar al-Jawlī* built in 1303 AD, in Cairo.

The types of cantilever muqarnas are as follows:

- A. The cantilever muqarnas with one row of a plainer type of muqarnas, which has one row of cascades of stalactites (Fig. 2.70 – A).

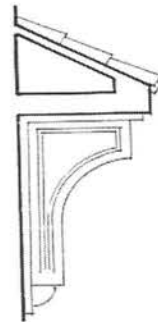


Fig. 2.70 - A

- B. The cantilever muqarnas with one row of a cascade of stalactite type, which has a quarter circling (divided into four parts), similar to a fan shape, based on two horizontal and vertical holders, with a right angle (90°) down to the existing vertical cantilever, with one row of muqarnas (Fig. 2.70 – B).

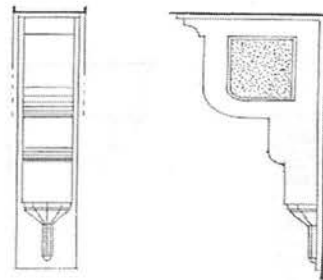


Fig. 2.70 - B

- C. The cantilever muqarnas with one row of a concave composite type, adorned by vegetal design, which is based on two horizontal and

vertical holder panels, with a quarter circling of cantilever with one row of muqarnas (Fig. 2.70 – C).

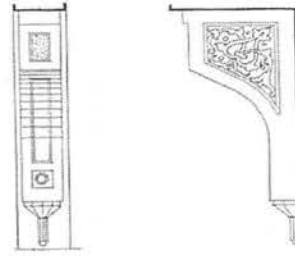


Fig. 2.70 - C

- D. The cantilever muqarnas with two rows of a cascade of stalactite type, which has two quarter circles, one big outer circle and one small inner one, similar to a fan shape. The perimeter of the outer quarter circle is divided into circles and is joined with the inner quarter circle, which is based on two horizontal and vertical cantilevers, with two rows of muqarnas (Fig. 2.70 – D).

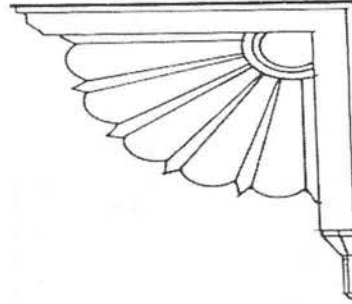


Fig. 2.70 – D

- E. The cantilever muqarnas with two rows of a concave composite type, which is divided into four parts, similar to the band shape. Three parts are based on three-quarter circle holders and are linked with a right angle (90°), and the fourth part is based on two rows of muqarnas (Fig. 2.70 – E).

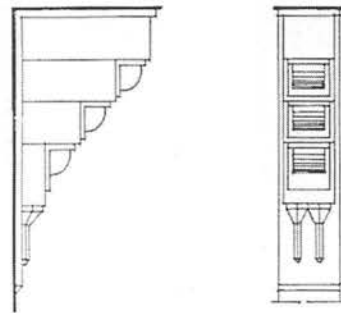


Fig. 2.70 - E

- F. The cantilever muqarnas with three rows of a prismatic composite type, which has three tiers of cascades of stalactites, based on

holder panels and on horizontal and vertical staircases, adorned by vegetal design, with three rows of muqarnas similar to the frustum of a pyramid shape (Fig. 2.70 – F).

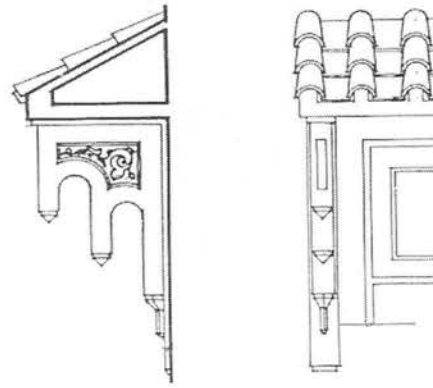


Fig. 2.70 - F

G. The cantilever muqarnas with three rows of a concave composite type, which has a quarter circle of a cantilever based on horizontal and vertical holders, with three rows of muqarnas (Fig. 2.70 – G).

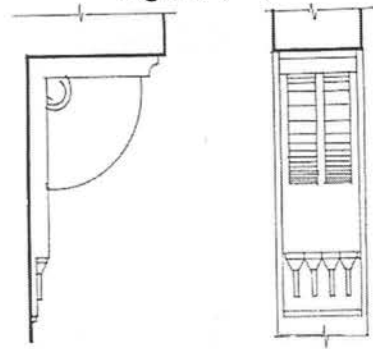


Fig. 2.70 - G

H. The cantilever muqarnas with five rows of cantilever muqarnas, of a cascade of stalactites type, which has five tiers of cascades of stalactites on holder panels at the two sides of the cantilever. It is based on horizontal and vertical staircases adorned by vegetal design, with one row of muqarnas at the end of the rows, similar to the frustum of a pyramid shape (Fig. 2.70 – H).

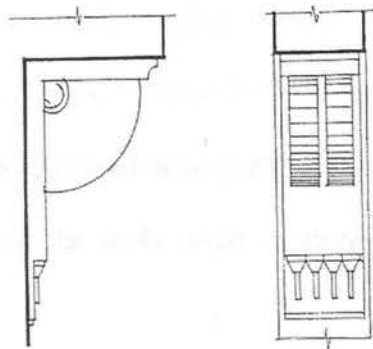


Fig. 2.70 - H

- I. A large size of cantilever muqarnas of a concave or prismatic composite type, which has two large tiers of muqarnas, each tier having two layers of stalactite cascades, and adorned by vegetal design, based on horizontal and vertical holders, with one tier of muqarnas at the end of the cantilever (Fig. 2.70 – I).

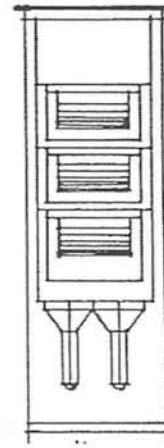


Fig. 2.70 - I

### 2.7.7. Implementing of the muqarnas in mihrabs

A mihrab is "a prayer niche built into the *qiblah* wall (facing Makkah) of a mosque" (Encyclopaedia Britannica, 2007), in order to indicate the direction of the *Ka'aba* (the house of Allah) in Makkah. It is where the *Imam* stations himself to lead the congregation in prayer. The mihrab is "an important element in any mosque, and normally there is only one" (Looklex Encyclopaedia, 2008), because it functions as the focal point of the prayer ritual. Its decoration is executed with great skill and devotion. Mihrab forms may have been derived from the niche used to store the *Torah*<sup>xiv</sup>

In synagogues, and there may have been some influence from the apses of Christian churches. Also, "the structure was adapted from the prayer niches common to the oratories of Coptic Christian monks. A mihrab can come in various shapes (flat, semicircular, polygonal, rectangular, etc.) (Encyclopaedia Britannica, 2007).

It is usually ornately decorated with geometric or foliated sculpture or tiles or muqarnas vaults.

The mihrab became the central feature of any mosque and of all sacred art and architecture in Islam, and its decoration was often embellished with the latest artistic techniques and material (e.g. stucco, polychrome glazed tiles, carved woodwork, glass mosaic, marble inlay and muqarnas vault). The designs were usually epigraphic and often geometric or vegetal, and also, it can be either flat or a concave recess in a wall.

According to *Tabari's* exegesis, "the earliest flat mihrab appeared pre-Islam, as in the Dome of the Rock, in AD 691, in Jerusalem, during the reign of *Khalif Abd al-Malik*" (Tabari, (1879–81), p. 2408). While other archaeologists are likely to trace "the earliest flat mihrab to *Uq'abah bin Nafie*, in the *Qarouan* of the Great Mosque, built in AD 670, in Tunisia" (Fikry, 1936, p.54), Creswell traces the first concave mihrab to the Prophets Mosque at Madina, in Saudi Arabia, for the Umayyad governor *Omar bin Abdul-Aziz* at the Umayyad caliph of *al-Walid I*, in AD 704–717 (Creswell, 1989, p. 53). Other examples can be found in the Umayyad mosques and palaces, such as the *Qasr al-Hayra ash-Sharqī* (East) Palace, built in AD 727–9, in Syria, and the *Mshattā* Palace, built in Jordan in AD 744. Another example can be found from the Abbāsīd period, in the *Ukhaydir Palace*, AD 777, in Iraq (Creswell, 1989, p.128).

The earliest mihrab in Egypt can be found in the mosque of *Ibn Tūlūn*, AD 876–79, in Cairo. "It has a stucco moulding and two stucco bosses on each side of the arch, and the inner decoration of the niche consists of an upper decoration of painted wood, a band of glass mosaics with the text of the *shahāda*, and a lower part made of marble panels" (Abouseif, 1989, p. 54). The mihrab form became widespread throughout the Islamic world, and was embellished with artistic techniques and materials.



A brief summary of the mihrab form of muqarnas in each area is required. In Fatimid Egypt, the mihrab developed into a distinctive form and was always enhanced architecturally, either by a dome above it, such as in "the oldest mihrabs in al-Azhar mosque, AD 970, in Cairo" (Abouseif, 1989, p.10). It is lavishly decorated with stucco inscriptions and arabesques on the arcades. Another example from the *Ayyubid* period in Egypt can be found in "the concave mihrab of the madrasa of Sultan *al-Sālih Najm al-Dīn Ayyūb*, from AD 1243, built by *Shajarat al-Durr*, in AD 1250, in Cairo, which is decorated outside with triple frame borders of prismatic composite muqarnas" (Abouseif, 1989, p.92) (Fig. 2.71), the author has visited this place, in February, 2002.

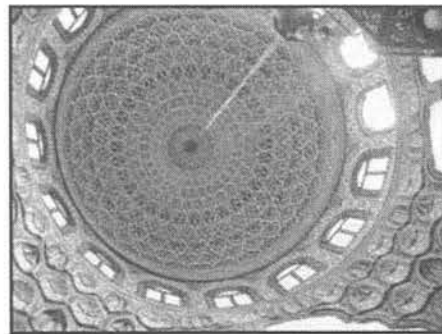


Fig. 2.71. Azhar mosque, in Cairo

Various types of mihrabs used muqarnas and became widely used in Ottoman architecture during the mid fourteenth century in *Konya* and *Adirna* mosques. "The earliest innovation regarding the mihrab in the Seljuk period occurred in Anatolia, and was the concave niche; its semicircle starts above and consists of an inner decoration with various tiers of muqarnas" (Shafie, 1970, p 154). The earliest example of the concave mihrab muqarnas appeared in pre-Ottoman architecture, in the *Karman* madrasa at *Nigde*, AD 1275, in Konya, and in the second half of the fourteenth

century at the *Hüdavandigār* Mosque, in Bursa, in Turkey. Other examples, with many forms and designs, can be found in the Anatolian mosques such as the muqarnas mihrab in the *Ash'kali Khan* mosque, AD 1249, in Avenue, which has a polygonal-shaped mihrab with five tiers of muqarnas, in a concave niche recess in the wall (Fig. 2.72). A further example of a mihrab of muqarnas type is in the *Kartā'ay* madrasa, AD 1250, in Antalya in south Turkey, which is a polygonal and pointed arch, with five tiers of a prismatic composite muqarnas vault, that slopes and overlaps the mihrab (Fig. 2. 72).

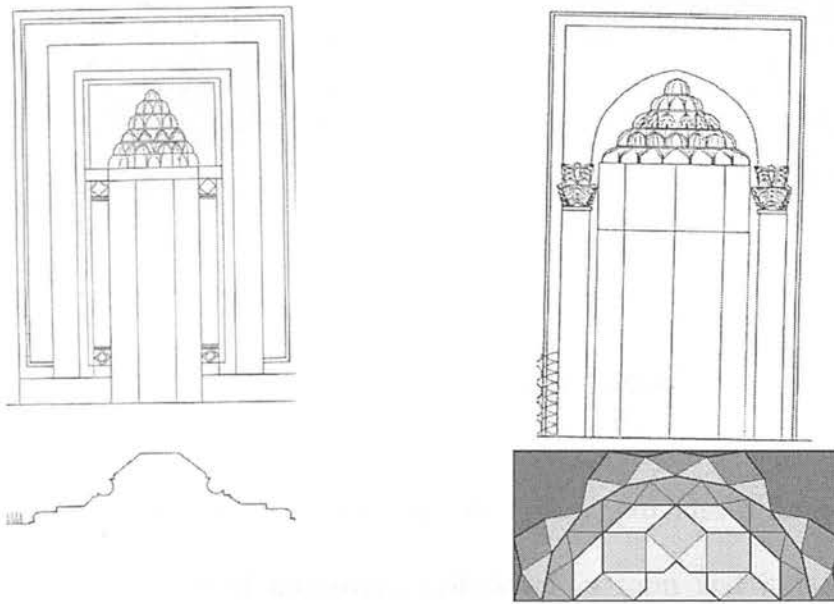


Fig. 2.72. The mihrab of Ash'kali Khan mosque and the Kartā'ay madrasa

The *Arab-Bab* (gate) mosque, AD 1279, in Kirby, in south Turkey, is another example. It is hexagonal, with five tiers of prismatic composite muqarnas vaults overlapping the mihrab; the first row has twelve muqarnas, the second row, ten, the third row, eight, the fourth row, six and the fifth row, four muqarnas. The great mosque of *Üllo-Jāmī* in AD 1399 in Bursa has a half-square-shaped mihrab and is divided into grades in the front elevation of the mihrab by small rectangle shapes from top to middle. The niche is filled with seven tiers and different muqarnas, which in the

first row have small squares between each muqarnas, the second row has stalactite muqarnas from the third row, and from the third to seventh row (last) there are normal tiers of muqarnas; as well as in the third row, eight muqarnas, the fourth row, five, the fifth row, three, the sixth row, two and in the seventh row, one muqarnas (Fig. 2.73), the author has visited this place, in August, 1999 and 2005.

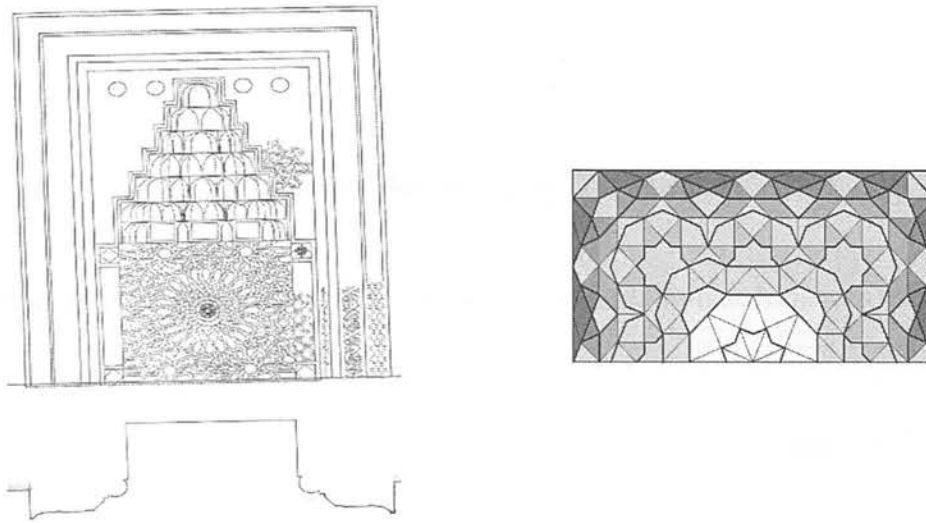


Fig. 2.73. The Üluo-Jāmī, in Bursa

The *Call* mosque, in *Hasan-keyf*, 1394 AD, in Turkey, provides a further example with a distinctive mihrab of muqarnas, cylindrical in form and it is formed by muqarnas in-between the architrave (separated by a column) and in the band cornice of the mihrab. In the capital of architrave columns with three rows on the muqarnas, and in the higher apsidal recess, five rows of a muqarnas vault overlap the mihrab. Each muqarnas is divided into two smaller muqarnas, which are in the second row cascade of stalactites of the first row of muqarnas. The higher muqarnas of the overlap takes a flat form and is divided into three smaller muqarnas from each muqarnas, which consist of a four row cascade of stalactites to the third rows of the muqarnas, the same as the lower one (Fig. 2.74).

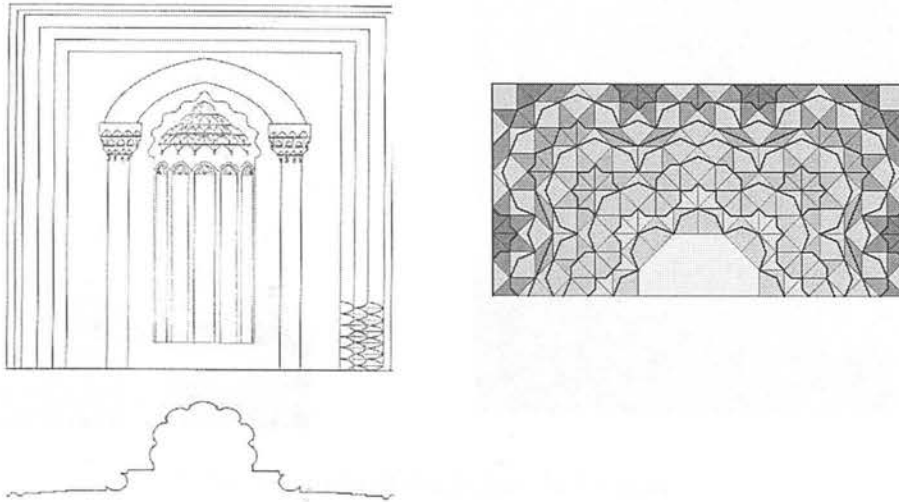


Fig. 2.74. *Hasan-keyf* in *Call* mosque

The other example of the mihrab, can be found in the Ottoman Mosques of the *al-Selimiye* mosque, in 1574 AD, in Edirne in Turkey. Other example can be found in the mihrab of muqarnas in the complex of *Süleymaniye* in 1557 AD, and the Complex of *Sultan Ahmet* in 1616 AD in Istanbul.

In Persia Iran although most mihrabs were made of stone, stucco, polychrome glazed tiles, carved woodwork, glass mosaic and marble inlay. The greatest memorial to their achievement mihrab, is the mosque of *Lutfallah*, in 1603-19 A.D, in the Maidan Isfahan, in Iran (Fig. 2.75).

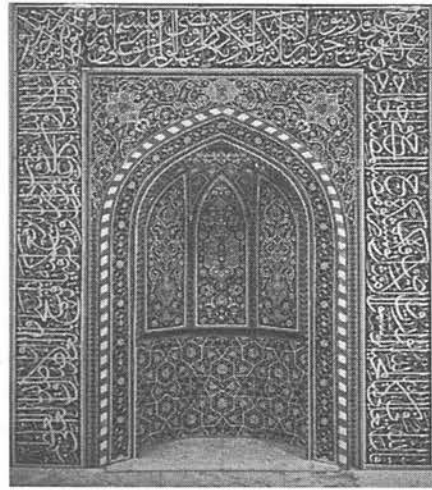
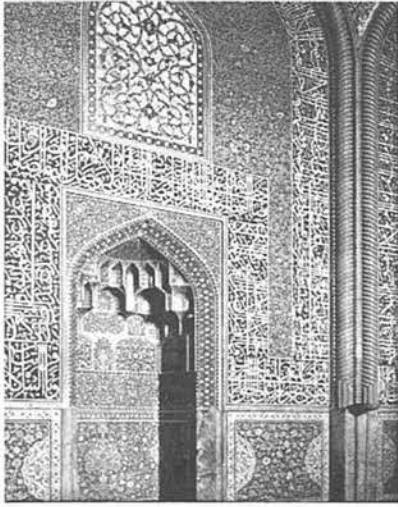


Fig. 2.75. The mihrab *Lutfallah*, in Isfahan.

In India, the mihrabs have been built by stone, stucco and wood, and are often elaborately carved. The great harmonious mihrab decorated with muqarnas can be found in the mosque of the Tāj Mahal, 1632-54 AD, in Agra in India, which is decorated with triple frame borders of concave composite muqarnas and contrasts with the white marble (Fig. 2.76).

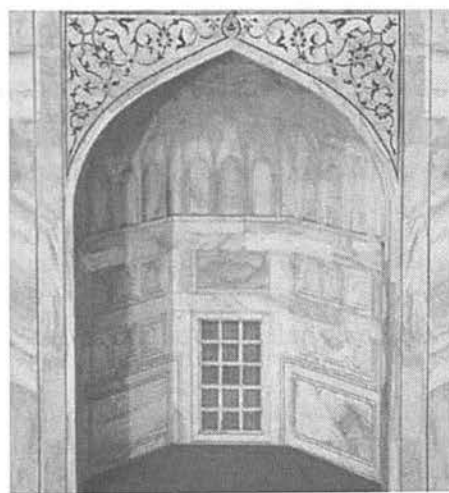


Fig. 2.76. The mihrab of Tāj Mahal, in India

In Northwest Africa, mihrabs of muqarnas are built of stone, stucco and wood, an example of a stucco mihrab of muqarnas can be found in Fez, Qarawiyyin Mosque, 1135 AD, and in the madras of *Bo-Inaniyy*, 1350 AD, in Fez as well.

There is also an early association of the mihrab and minbar, with the minbar placed next to the mihrab, possibly to lend spiritual authority to the sermon. In some areas such as East Africa, the mihrab is linked to a recessed minbar niche so that the imam climbs the minbar by entering a door in the side of the mihrab. This arrangement, however, is extremely unusual as the mihrab should be kept free of any mystical connotations.

#### **2.7.8. Implementing of the muqarnas in minbars**

The minbar is a type of pulpit usually found in a mosque, which is used for *khatib*<sup>xv</sup> (speeches) and when *khutba* (proclamations) are made. Minbar is the Arabic word that describes a raised platform; it is situated to the right of the mihrab and consists of a platform reached by steps. Often there is a door at the entrance to the steps and a dome or canopy above the platform. "The earliest historical reference to a minbar states that in 629 the Prophet made a minbar from which he used to preach to the people" (Minbar, [archnet.org/library](http://archnet.org/library), 2008). This minbar consisted of two steps and a seat (*Mak'ad*) and resembled a throne. The Prophet Muhammad in 682 AD. (God's praise and peace be upon him) is said to have delivered his addresses leaning against a palm-trunk fixed in the ground, "It was a chair consisting of three steps, on the third and last of which the Prophet used to sit, keeping his feet on the second" (Creswell, 1989. p.5). "This continued under the last few years of Umayyad rule until in 750 AD, the caliph *Mu'awiya* ordered that it should consist of six steps (Maher, 1985. p.181).

Most minbars are made of wood, stone, marble and alabaster with outstanding decoration, and are highly decorated whilst those made of stone or brick tend to be much simpler and often comprise a bare platform reached by three to five steps. "The earliest extant wooden minbar is that in the *Qairouan* great mosque, 862 AD, in Tunisia" (Michel, 1991, p.220), which is a fairly simple design without a gate or canopy and consists of seventeen steps leading up to a platform. Other early wooden minbars examples can be found in Egypt, in the Mosque of 'Amr ibn al-'Ās, 827 AD, in Cairo, from the *Circassian* Mamluk period in the minbar of the Mosque of Sultan Faraj Ibn-Barqūuqe, 1409 AD (Lamie, 1984, p. 82), which ends up with a chair for the Imam on the upper part of the minbar and a bulbar-domed canopy above the platform; it is flanked with three rows of muqarnas in the upper part of the doorway at the entrance to the stairway of the minbar. An admirable example of a wooden type of minbar with a masterpiece of wooden muqarnas is that of the *Aqsa* mosque in Jerusalem built for *Nur al-Din*\* in 1168 AD (Alwaly, 1988, p.847), which are four rows of muqarnas on top of a doorway at the entrance to the stairway and three rows of muqarnas on the cornice of a square canopy above the platform (Fig. 2.77).

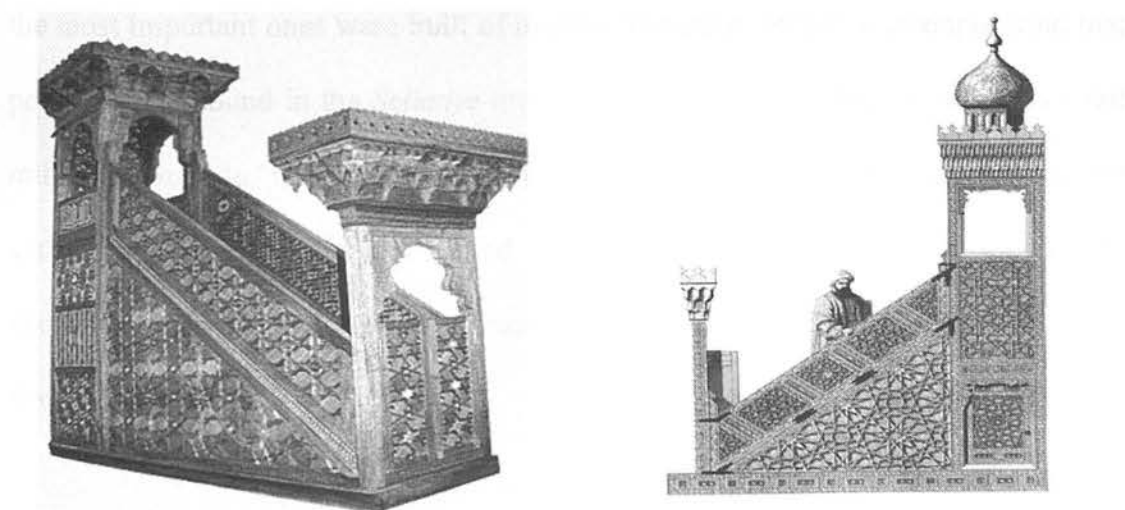


Fig. 2.77. The minber of the *Aqsa* mosque in Jerusalem



In the Circassian Mamluk period, geometrical decoration was used with "a conch and inlaid design wooden work that rests on a small vault with 'dripping' muqarnas, such as the minbar of the madras of Sultan *al-Mu'ayyad*, 1418 AD, in Cairo" (Lamie, 1984, p. 45). Another example of the minbar style in stone is at the mosque of *Sultan Hassan*, 1356-61 AD, in Cairo, which is over the doorway to the minbar and also in the mihrab with three rows of muqarnas carving (Fig. 2.78).

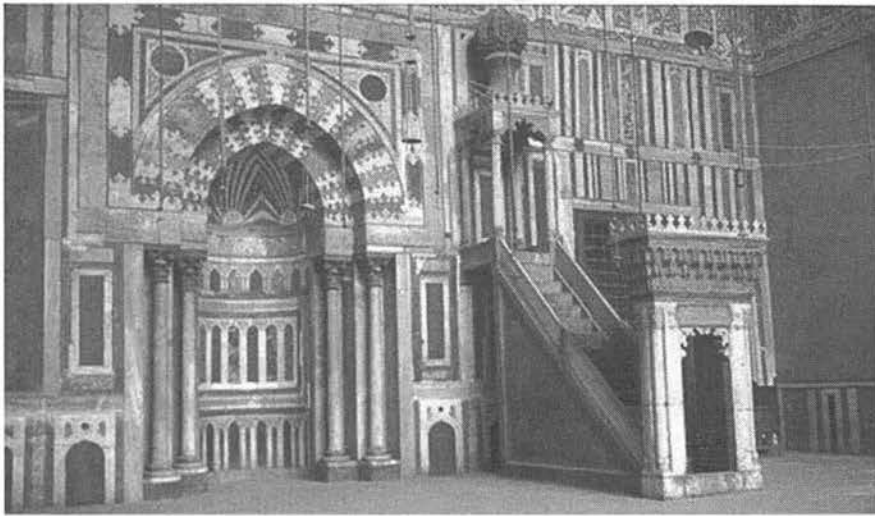


Fig. 2.78. The minber of the mosque of Sultan Hassan, in Cairo.

In the Ottoman period in Turkey, although most minbars were made of wood, some of the most important ones were built of marble. The most attractive example from that period can be found in the *Selimiye* mosque, AD 1569–75, in Edirne, which is a tall minbar of marble, with three rows of muqarnas on the top of a doorway at the entrance to the stairway. It is carved with three rows of muqarnas on the canopy above the minbar domes; its steep stairs and tall hood are all characteristic Ottoman features.



### 2.7.9. Implementing of the muqarnas in furniture

One of the most significant current discussions in Islamic arts relates to the use of the muqarnas in interior design and decoration, such as in tables, chairs, or in the ceiling of a room to decorate the light, or in a door *Shaahiya* (cap or tag corner). The muqarnas design in furniture is one of the most beautiful pieces of art. Most of the decorations are made of wood with muqarnas details. The most striking example of applying muqarnas in furniture can be found in the table in (Fig. 2.79), which has taken three rows of the muqarnas surrounded the elevation of the table.

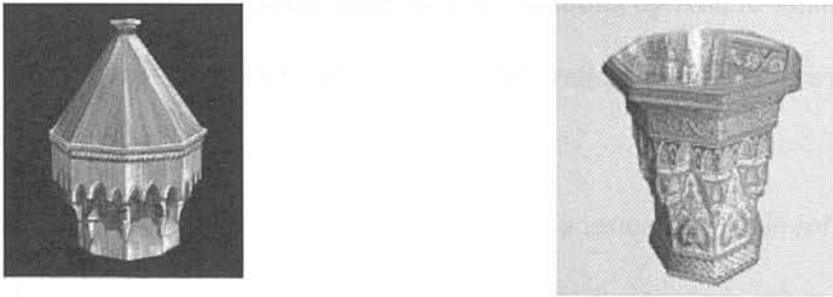


Fig. 2.79. Table and ceiling decoration by muqarnas

Another example can also be found on the ceiling of a room, decorating the light with muqarnas detail (Fig. 2.80, photographed by the author in the Sheraton Hotel lounge in Jeddah, in Saudi Arabia, in January, 2004).

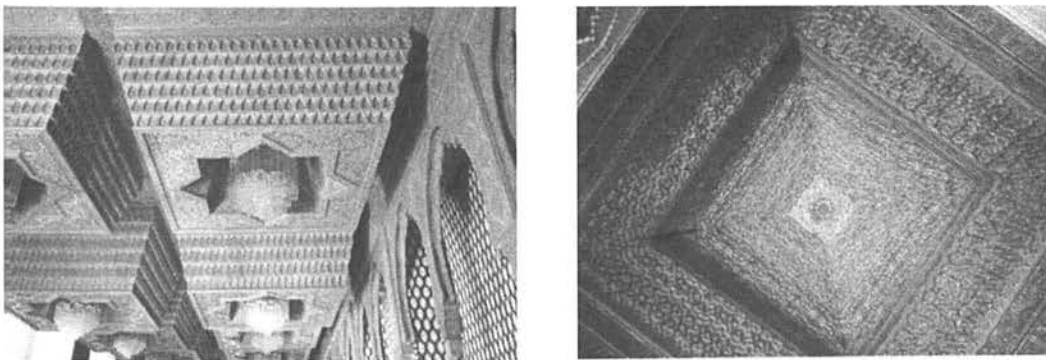


Fig. 2.80. Ceiling decoration by muqarnas

## 2.8 Materials necessary for the implementation of muqarnas

The muqarnas was used by Islamic masons and artisan carvers since it allowed them, through their abilities, to deal with different materials and to apply their use to various architectural situations. They adapted the raw materials to forms of architectural decoration that involved different artistic techniques and materials (e.g. plaster-carved woodwork, polychrome glazed tiles, mosaic, marble inlay and metal inlay). The forms of muqarnas designs were usually epigraphic and often geometric or vegetal, and sometimes were of figurative imagery. The combination of muqarnas forms and techniques allowed a range of developments and variations by Arabic-Islamic masons and artisan carvers, and became a form of ornate decoration in architecture and art.

There are two basic methods of approach to carving a muqarnas, *indirect* and *direct* carving. In indirect carving, the muqarnas is first made in some other material – usually a plaster cast is taken from a clay model – then it is transferred more or less mechanically into stone pointing. Where the indirect method of constructing the muqarnas is used, the actual cutting of the marble may be done by artisan carvers or workshop assistants and need not be done by the artist himself.

Direct carving of the muqarnas is then a process of releasing superfluous material from a block to reveal the shape the artist has conceived as a latent form within the block. The way in which an artist releases this image depends on his own imaginary concept. The different materials, their implementation and the method of muqarnas which are regulated by the raw materials are as follows:

### 2.8.1 Gypsum (plaster)

Gypsum is a very soft natural mineral composed of hydrated calcium sulphate (to the chemical formula  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) (Oster, & Frenkel, 1980, pp. 41 -45). Gypsum can form when limestone is attacked by sulphuric acid. The Arabs called it *Ja'sa*; the Persians *Ka 'a*, and the Turks *Al'çī*. Plaster decoration in Europe is made in moulds. Muqarnas and other motifs are always prefabricated, and then installed. Gypsum is one of the most widely used minerals in the Islamic world and worked by carvers on the spot. Gypsum work thus became a noble art and is one of the chief elements in palaces, mosques and a variety of buildings. Most carvers used gypsum in implementing the muqarnas because it provided more flexibility, and it was the most common way in which an object could be processed for casting. Methods of approach to gypsum carving involve *indirect* carving. According to some *maallems*, or artisan carvers, the casting and moulding process of the muqarnas is as follows:

1. Create a shape frame model of the muqarnas.
2. Carve the elements of the muqarnas in this shape frame, starting from the external large elements and working in to the inner small elements (the muqarnas appear as high up in the upper part of the work), and keep this model for future use.
3. Cast the original model from a shape frame model and fill in all hollows, then take out the shape frame model to use it again in any form.
4. Copy a negative mould of muqarnas in the walls, to use the same copies that same designed by use the same shape frame model to make other copy.
5. Paint all muqarnas copies in any colour suitable for the traditional locality.

### 2.8.2. Marble

Marble is "a metamorphic rock resulting from the metamorphism of limestone, composed mostly of calcite (a crystalline form of calcium carbonate,  $\text{CaCO}_3$ )" (Oxford English Dictionary, 2007). The Arabs called it *marmare*; the Turks *marmae*; the Greeks *marmaros*: a crystalline rock, from the Arabic word *marmairein*, to sparkle, and from *Murakhem* (the person performing the marble work). "Marble is widely spread worldwide and exists in a wide variety of colours and patterns, the latter resulting from the presence of matter other than calcite" (Osborne, 1970, p.691).

Generally, marble has been used for buildings, by sculptors and for their carving, as a hard crystalline metamorphic rock and as a softer white material that is easily cleaned. "The best known sources of marble are Turkey, the Middle East, Asia, North Africa and some European countries, and it has various names and qualities (e.g. pure white *Carrara*, *Pentelic*, *Apollino*, *Rosso*, *Verde* and *Belgian* black) (Osborne, 1970, p. 692).

The classic technique of use by artisan carvers is as follows: (1) once mined from the quarry, marble is transported to be carved in huge slices or blocks with machinery; and (2) the traditional stencil procedure is used by *Maalem* (craftsman) to draw the basis of the muqarnas. Then the muqarnas blueprint is drawn right on the marble itself and, as the subject emerges, the craftsman retraces and reworks the drawing; and (3) the craftsman uses his chisel or a graver to trace his design, or he outlines directly, using special tools such as a saw with a serrated edge, pick or mallet; (4) once the carving proper has been completed, then comes the polishing, with a power-driven disk moving across the surface using scraper tools<sup>xvi</sup>, such as a rocker with a serrated edge, and sandpaper, where lighter tones are required; and (5) then comes the shine

which must be quite smooth and is achieved by use of a wet fabric with saltpetre and sulphate.

The method of marble carving of muqarnas has many forms, which craftsmen have developed throughout the history of Islamic art. Islamic architecture used marble muqarnas to provide continuous carved surfaces, leading one surface to another, or serving to give linear emphasis to a portion of a vertical or horizontal surface. Marble muqarnas were used as ornamental frames of projecting niches, and for cornices to architraves to resolve the change in transitional zones between various surfaces, and in capitals, columns, ceilings, domes, minarets, and mihrabs in a variety of shapes and forms with unique geometric arrangements and with direct carving (Fig. 2.81).

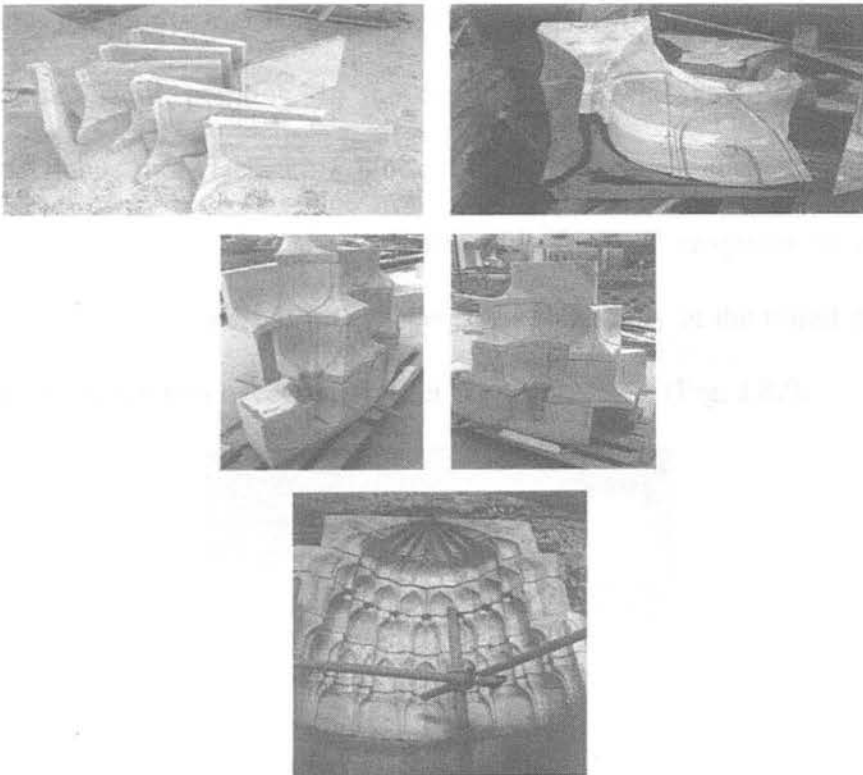


Fig. 2.81. Assembling muqarnas marble in make mihrab.

### 2.8.3. Stone

Stone is composed of pure soil oxides. It exists in underground layers formed of essentially metallic compounds, and it has a greater density than water. Stone occurs worldwide and in many varieties that differ in texture and thickness. The stone that is used in muqarnas introduces ornament to underline the structural beauty of the decoration of the building.

There are basically two stone carving methods in relation to muqarnas, *indirect* and *direct* carving. An indirect method is the practice of making a small preliminary figure in clay, wax, or a comparable material, which is used as a general guide for the sculptor when cutting his stone block. It is a process whereby muqarnas are fashioned in a soft and malleable material, and which is then transferred more or less mechanically into stone pointing. In the direct method, it involves a process of releasing superfluous material from a block to reveal the latent shape the artist has conceived within the block, and then releasing the form of muqarnas as a set of profiles fitting within the block; if he conceives the form fully in the round from the beginning, his approach will necessarily differ (Paccard, 1981) (Fig. 2.82).



Fig. 2.82. The artisan carving muqarnas stone

## **A Limestone**

"Limestone is a sedimentary rock composed essentially of carbonate of lime" (Osborne, 1970, p. 660). It varies in hardness from easily worked, quickly weathered lays and freestone, to fine-grained. Limestone is an important stone for building and its many types have been used in elevations of buildings, such as Bath stone, Cane stone and Travertine, etc. and it occurs in different colours – white, yellow and red. Limestone has been used comparatively infrequently and as a small-scale treatment of the muqarnas element for the carved surfaces of elevations of traditional buildings and entrances.

## **B Sandstone**

Sandstone is a consolidated rock that is composed of sand grains welded together by a calcareous material that acts as cement, the solid masses being hard enough to serve as building stones. Sandstone varies in colour, depending on the nature of the sand and of the cementing matter. Ferruginous sandstone ranges in hue from grey or yellow to greenish in tone. The warm colours of the stone and the fact that it is readily workable have enhanced its popularity for building and muqarnas. Sandstone is widely distributed and local variants differ considerably in their qualities and appearance.

The carved decoration of muqarnas by sandstone used the direct method, which is a process of releasing the form of the muqarnas as a set of profiles fitting within the block. They are similarly used in the decoration of limestone and marble, and also, in the tools and techniques of stone carving of muqarnas. The technique of muqarnas types and forms depends on the function of the artefact or building they decorate, and they can be invested with an iconographic function (Gonzalez, 2001).

#### 2.8.4. Wood

Wood is a solid material that is derived from woody plants, and has been an important construction material since humans began building shelters, houses, and boats and it has a diversity of uses (Hoadley, 2000). Wood has been extensively used for architecture, architectural decoration, cult objects and furniture that is designed to complement architecture. Wood usually has a distinct structure as a supporting material, especially in roof constructions, in interior doors and their frames, and as exterior cladding, such as used in muqarnas as an architectonic form and as applied ornament. In the Islamic world, there is a wide range of high and good-quality wood, available and suited for carving muqarnas. There are two kinds of wood suitable for muqarnas, (1) softwood (e.g. pinewood and cedar); and (2) hardwood (e.g. beech, oak, teak, walnut and ebony).

There is a principal wood-carving technique for muqarnas, where the craftsman transfers his drawing of the design of the muqarnas onto the smooth, flat surface of a block of wood and carves away by *direct* carving (e.g. Italic-, deep-set, and raised-carving<sup>xvii</sup>), resulting in muqarnas ornamentation of a wooden object. The essential equipment for muqarnas wood carving is very simple indeed, a flat chisel, a graver (e.g. gouge, pick, adze), a knife, and block plane. This wood carving technique for muqarnas is similar to the approach taken with regard to stone and marble material, namely, indirect and direct carving. The craftsman uses his equipment to carve and trace his muqarnas design (Fig. 2.83), the author has visited this carpenter's workshop, in Casablanca, in Morocco, in March, 1995.



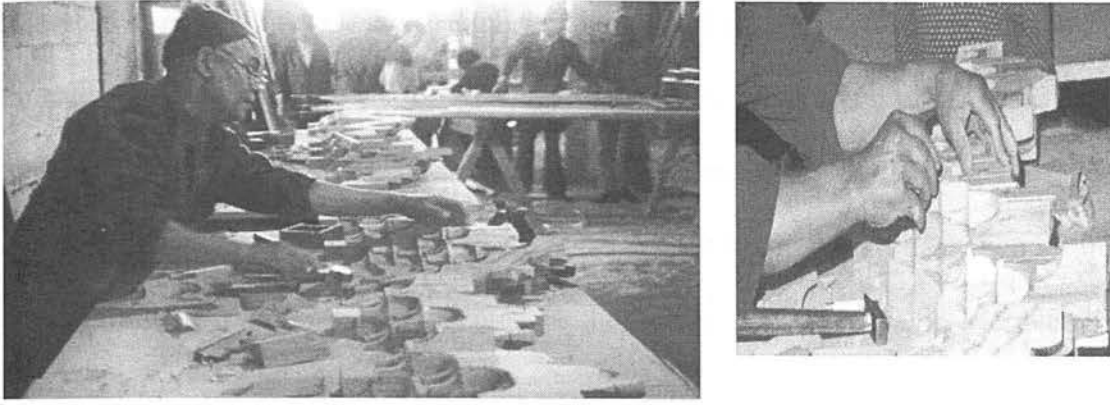


Fig. 2.83. Construction wood of muqarnas detail by artisan on the lap.

In the Arabic-Islamic world, skilled practitioners of carpentry (*Naggar*) have learned to adapt and use figure carvings. Professional artisan woodcarvers show their ability to deal with different wooden materials and put different qualitative types of wood to good use; there are also many different names for carpentry, such as *Mu'taim*, *mu'rasai*, *Khrat*.

Painting the wood of the muqarnas is the most popular way of decorating and protecting the material. Properly looked after, applied and decorated, it gives the wood of a muqarnas a highly attractive appearance and also provides excellent protection against humidity, dust, insects, and general wear and tear. Coloured paint, or oils, stains or varnishes can be used to enhance its looks.

### 2.8.5 Metal

Metallic materials have played a major role in interior and exterior decoration in architecture and furniture, and include any of a class of elementary substances, such as gold, silver, or copper, all of which are crystalline when solid. These elemental metals were used to decorate muqarnas doors/windows, lintels, glass windows, lamps,

mihlabs, minbars, Dikkas, etc. Metal was also used as a decorative technique for muqarnas on ceilings or walls or streets. It was also used in some of the functional elements of interior and external design, for example in table structures and chandelier, lantern, door and window designs (Fig. 2.84), the photo has taken by the author, in the gate of King Hussein presidential Palace in Casablanca, in Morocco, in March, 1995.

The designs are created in a similar way to the approach taken with regard to gypsum material, in terms of indirect carving. There are a few examples of lantern muqarnas in furniture, most of which are made of copper. They take the normal rows of the muqarnas, depending on the elevation of the ceiling and decorative style. Different materials and different techniques are used to present their best qualities.

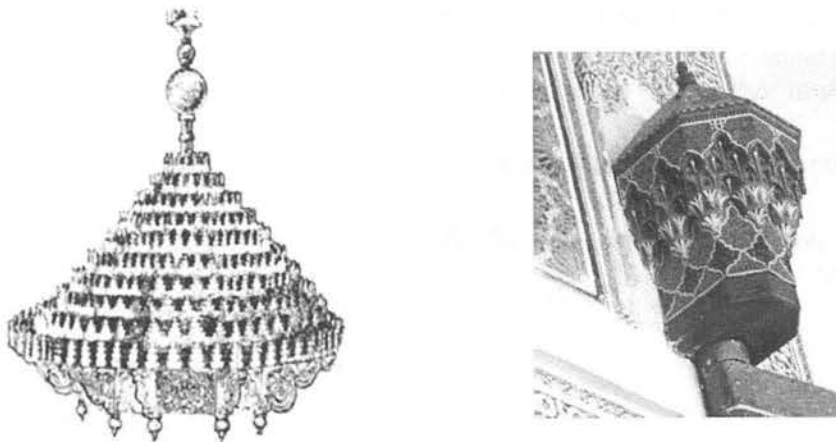


Fig. 2.84. Metal lantern designs and door designs of muqarnas

## 2.9. Conclusion of Chapter Two

The term “muqarnas” is the transcription of an Arabic word that is usually translated by “stalactites” or “honeycomb-cell”. The origin of the Muqarnas can be seen in the stalactites formed by water dripping inside caves and providing superb and admirable

shapes. The expression of this beauty has come into architecture in the Muqarnas whose motifs give the same impressions as natural stalactites. Thus the Arabs have known how to add a natural element to interior architectural ornamentation.

The idea of the muqarnas is related to the emergence of the dome, as a transitional zone between various surfaces, and also between the surfaces of horizontal and vertical angles, as a solution to making the transition from a square to a circle and vice versa, and in order to hide hard edges. As a result of this approach, two methods appeared: the squinch method, or 'concave niche corner' or quad-dome, and the pendentive method using 'spherical triangles'. The unit is split up into smaller units, each derived from the original, and these small units are in their turn filled by miniatures of themselves; with the repetition of this small spherical inclusion at each of the corners, complete unity was achieved. The two inner forms in the construction were joined by the system of moulding which arises from the muqarnas. The innovation of the two methods has been regarded as a good feature by Arab architects, and has been applied in buildings in the Middle East: Iran, Iraq, Syria, Turkey and North Africa. an Islamic innovation

The historical origin of the muqarnas is little known, this unique feature of Islamic architecture has founded the oldest examples in Riga, in Syria, dating from the 8th century. Then they spread throughout the Islamic world to become one of the elements of Islamic architecture from the 12th century.

The admirable examples in Egypt, which go back to the time of the Mamluke period, and which are carved into the stone. The Turks and the Seljuk also used them : they

are admirable examples from the form. The most fabulous examples are those of the Alhambra in Cordoba in Spain.

The chapter has shown how this unique feature of Islamic architecture is used both for architecture and ornamentation, as a decorative motif and as an enriched block or horizontal bracket, that was implemented in arches, capitals, windows, ceilings, domes, minarets, and mihrabs in variety of shapes and forms with unique geometric arrangements.

They are generally built local materials used for construction such as stone, brick or stucco. The material may be left as it is or covered with coloured ceramic, as in the Persian Islamic structures, or with glass, as in certain Islamic structures in Najaf and Karbala, in Iraq. Finally, they may be built of wood and form decorative motifs allied to certain ceramic elements, like at the peak of the entrance to a pulpit, or in certain furnishings

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i - Ibn Jubayr, (1145-1217), was a geographer traveller and poet from Andalusian.

ii - Stalactites has a "c" for "ceiling", and Stalagmites has a "g" for "ground". Stalactite is stretched "tight" (tight) by hanging from the ceiling. Stalactites have to hang on tight to the ceiling.

iii - By an Arabic form (ليس الإستريشال وباب مجصص. وغواشي على الرأس عليها مقرنص).

iv - By an Arabic form (بناء كأن النحل هندس شكله ولانت له كالشمع فيه ضخور).

v - Circumscribed circle: the mathematical term is associated with the circle inside the square.

vi - Firouzabad is a town of south-central Iran, in the province of Fars, 72 miles south of Shiraz, in 28° 51' N. Available from: < <http://www.en.wikipedia.org/wiki/Firuzabad>, > [Accessed 6, July, 2006].

vii - Zumurrud Khatoun tomb of the wife of the Caliph Al-Mustahdi Bi-Amrillah and mother of the Caliph Al-Nasir Li Dinillah, is located on the west side of Baghdad, in the Sheikh Ma'aruf district.

Zumurrud Khatoun tomb, Available from: < [http://www.atlastours.net/iraq/khatuns\\_tomb.jpg](http://www.atlastours.net/iraq/khatuns_tomb.jpg), >

[Accessed 15, October, 2006].

viii - Beemarestan is a Persian word composed of three syllables –Beemar – meaning (patient), - stan- meaning a place (the place where the patients are treated (hospitals)).

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ix - Halabi: a special type of staircase mentioned frequently in Mamluk documents, examples of which, however, are no longer extant. The name is derived from Halab (Aleppo), because the style was inspired from there.

x - Muezzin: the person summoning people to the mosque for prayers, the five-times daily prayers of Islam.

xi - Ad'han: Chant used to call all Muslims to prayer.

xii - Ablaq: a term used to describe alternating light and dark courses of masonry. The origin of this decorative technique may derive from the Byzantine use of alternating courses of white ashlar stone and orange baked brick. The technique of *ablaq* seems to have originated in southern Syria, where volcanic black basalt and white limestone naturally occur in equal quantities. Available from: <<http://www.touregypt.net/ablaq>> [Accessed, 28, November, 2008].

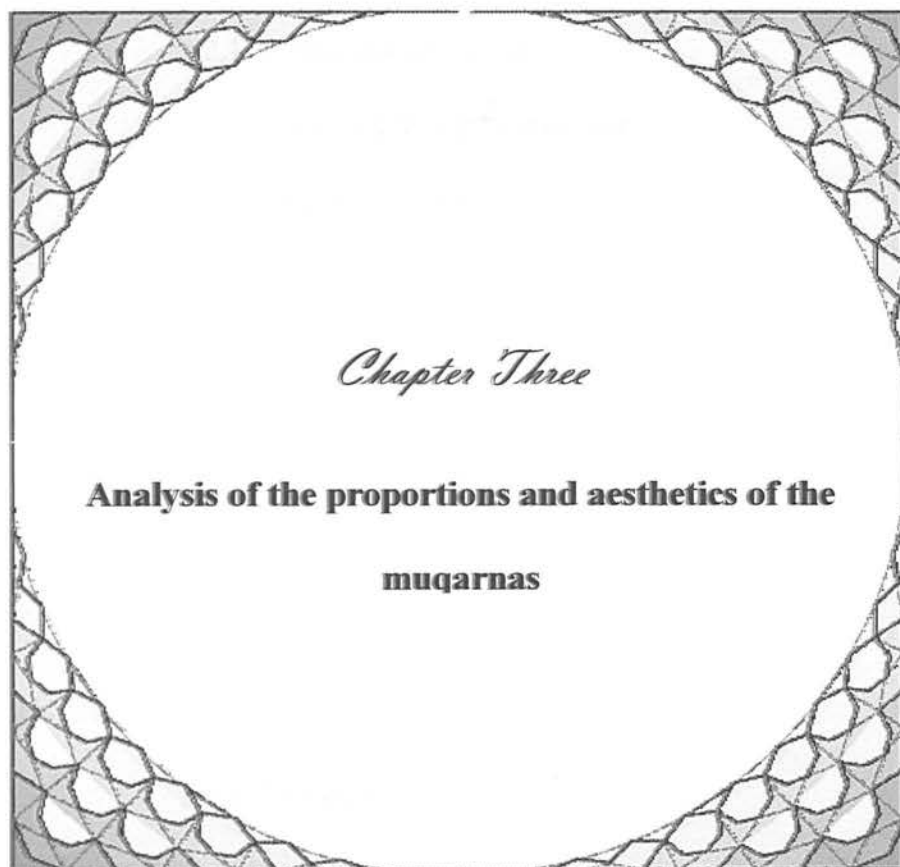
xiii - The word *Chemmassiat* is derived from the Arabic word '*chems*' meaning 'sun' *Chemmassiat* means diffused sunlight by means of coloured panes. Paccard Andre, '*Traditional Islamic craft Moroccan Arch*

xiv - Torah is a Hebrew word meaning "teaching" "instruction" or "law". It refers primarily to the Five Books of Moses. Philip Birnbaum, *Encyclopedia of Jewish Concepts*, Hebrew Publishing Company, 1964, page 630, (Available from :<<http://www.en.wikipedia.org/wiki/Torah>> [Accessed, 19, August, 2007]).

xv- Khatib: The person making speeches at the Friday sermon.

xvi - Scraper tools in the form of a three-bladed knife, are used by engravers and etchers to remove the burr from engraved lines or for making corrections by smoothing or scraping the surface. (Osborne, 1970, p. 1105).

xvii - The carving of deep-set and raised-carving has been known since Hellenistic times, from 323 to 27 BC.



## **Chapter Three: Analysis of the Proportions and aesthetics of the Muqarnas**

### 3.1. Introduction

### 3.2. The organic basis of the proportions of the muqarnas

#### 3.2.1. Simple numerical ratios

#### 3.2.2. Values of the summation series

#### 3.2.3. Geometric ratios

#### 3.2.4. Dynamic symmetry

### 3.3. The proportions of religious buildings

### 3.4. The proportions in architectural elements

#### 3.4.1. Arches

#### 3.4.2. Capitals

#### 3.4.3. Domes

#### 3.4.4. Mihrabs

#### 3.4.5. Minarets

### 3.5. The creation of muqarnas and the aesthetic aspect

### 3.6. Conclusion

### 3.1. Introduction

The objective of this chapter is to introduce a detailed study and analysis of the most important evident proportional order and harmony of each element in Islamic architecture, establishing which are the most important basic elements and ratios in the muqarnas units. These proportions should be considered as flexible in order to fulfil existing requirements in both planning and architecture.

The study turns its focus upon various surfaces of Islamic architecture, such as: arches, domes, capitals, windows, ceilings, minarets, mihrabs, minbars and façades. The extracted proportions reflect the relations between elements of the same kind, which include measuring the plans, elevation and section, compared with the muqarnas unit itself.

This will be achieved by presenting a range of ratios, starting with simple ratios, such as 1:1, 1:2, 2:3, 3:4, and so on. Another, much more interesting, set of numerical ratios of the muqarnas is the *summation series*, which starts by adding the first two whole numbers, 1 and 2, to get their sum, 3. The series builds by adding the sum of each of the preceding two numbers. So we get the series, 1-2-3-5-8-13-21-34-55-89, and so on, to infinity. A third possibility for analysing muqarnas ratio relationships is geometry. This method has often been used as a framework of related geometric shapes and construction lines to provide a template for their composition. Another approach for analysing the muqarnas ratio is the Golden Section. This can be expressed between any comparable qualities of form, tone and rhythm.



This chapter introduces some background information about the essence of proportional Islamic architecture, as found in the *Ikwan al-Saffa* (Epistles of the Brethren of Purity). Particular emphasis is placed on the sources for architectural design and their significance. This chapter will also discuss some implications of the aesthetic aspect of the muqarnas; a very strong relationship exists between the aesthetic and proportional bases of the muqarnas. There is an inherent mathematical structure to the muqarnas which makes them pleasing to the eye.

### 3.2. Organic basis of the proportions of the muqarnas

The idea of proportion derives from that of ratio, which is the simple quantitative comparison between two things of the same kind. According to the Oxford English Dictionary (2007), "in its most general sense, proportion is the measure of relative quantity; in its mathematical senses it is similitude or equivalence of two or more ratios.

Ratio is the relation between two things of the same kind, of which we know the measure of the one as compared with the other. We call a man father when we contrast him to his child and the latter a child when comparing with the father. Similarly, we call one thing half of another which is double of the former (El-Said, 1976, p.5).

Also, a ratio is expressed as  $a:b$  or represented as a fraction  $a/b$ , where  $a$  and  $b$  can be any number. Proportion is the equality of two or more ratios which can be either:

Continuous: e.g.  $a/b = b/c = c/d$  etc.  $2/4 = 4/8 = 8/16$  etc.

Or discontinuous: e.g.  $a/b = c/d = f/g$  etc.  $2/4 = 3/6 = 5/10$  etc.

Both have a constant characteristic ratio, in this case represented numerically as  $1/2$  (El-Said, 1976, p.6).

The rectangle is the most commonly used shape in design. Its characteristic ratio is expressed by the measure of its short side ( $a$ ) to its long side( $b$ );  $a:b$  can be any ratio, 2:3, 3:5, 5:6, 5:8 (Fig. 3.1).



Fig. 3.1. Rectangle ratio.

In a square,  $a$  and  $b$  are equal, and therefore the proportion is  $a/b = 1/1 = 1$ , i.e. unity. When constructing a rectangle, the short side ( $a$ ) of which is the side of a square and the long side ( $b$ ) is equal to the diagonal of that square, the ratio  $a:b$  is equal to  $1:\sqrt{2}$  (from the theorem of Pythagoras) (Fig. 3.2).

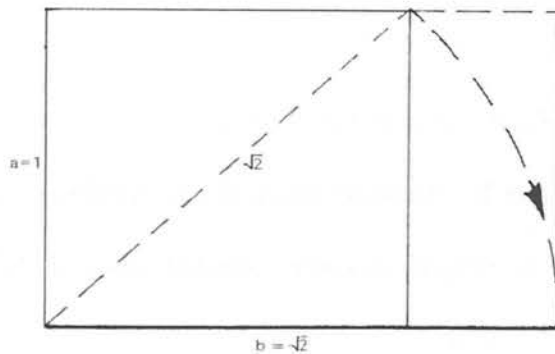


Fig. 3.2. The ratio  $a:b$  is equal to  $1:\sqrt{2}$  (squareroot2)

"The square root of two,  $\sqrt{2}$ , is called an irrational number because there is no rational number which, when multiplied itself (squared), give two. Therefore its approximate value will lie between two numbers one small and the other large,

i.e. 1.4	and 1.5
1.41	and 1.42
1.414	and 1.415
1.4142	and 1.4143
etc.	etc.

This led to the doctrine of the incommensurable which simply means that in theory the side and the diagonal of a square cannot be measured exactly using the same scale. In other words  $1:\sqrt{2}$  is not expressible as the ratio of two integers (El-Said, 1976, p.7-8).

The proportion is the relation of one part to the whole, or to other parts. 'Symmetry' in classical terminology meant the proportionality between the constituent elements of the whole. Since "the concepts of 'symmetry' are based on harmonic proportions, the linear numerical methods of analysis of geometrically constructed designs invariably result in approximation or inaccuracies because of the irrational numbers derived from the proportions of the geometric elements of the design" (Al-Bayruni, 1048, p.11).

In this chapter, the author will attempt to illustrate how the Muslim world proceeded to apply geometric principles to the practical problems of making muqarnas patterns such as movement, pattern and balance, between proportion and rhythm which are present in the organic forms of nature and function in design. The author understands that these aids are tools for clarifying the muqarnas' dependence on mathematics and geometry.

### 3.2.1. Simple numerical ratios

Scott, (1951) "Simple ratios, such as 1:1, 1:2, 2:3, 3:4, and so on, are directly perceived and felt. They can be expressed between any comparable qualities of form

and tone. For instance, a rectangle with a long side twice the length of its short expresses this kind of ratio. Such ratios are particularly subtle or dynamic, but they have their own simple strength. The concept of ratio is often restricted to comparisons of length and volume. This is too narrow an application. The same principle is equally valid wherever we have comparable qualities. In tone contrast, for instance, if value A is one step lighter than value B and two steps lighter than value C, we have a double ratio. The comparison from A to B to C is 1:1; from A to C it is 1: 2, (Fig. 3.3) (Scott, 1951, p.55).

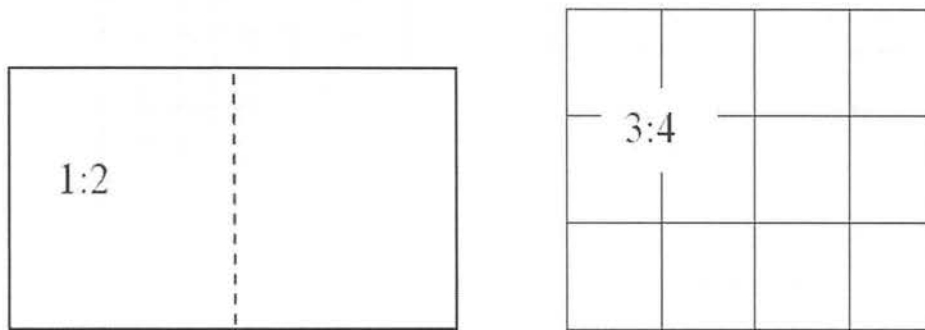


Fig. 3.3. Simple ratios

### 3.2.2. Values of the summation series

There is another, much more interesting set of numerical ratios of the muqarnas. It develops out of what is known as the *summation series*,

Which is built by adding the sum of the two preceding numbers. So we get the series, 1-2-3-5-8-13-21-34-55-89, and so on, to infinity. The particular property of this series is that it gives us the closest whole number approximation to mean and extreme ratios. The author can express what this means algebraically this way:  $A : B :: B : C$ . If we translate this into values from the series, we get: 1:2 : 2:3 or 2:3 : 3:5. From algebra we remember that the product of the mean must equal the product of the extremes. We see therefore, that our equations are inaccurate. In the first, the means are one more than the extremes; in the second, one less. This same error of one runs through successive steps of the whole series (21:34 : 34:55, or  $1155=1156$ ; 34:55 : 55:89, or  $3026=3025$ , etc.). At the beginning the error is great. As the series

progresses, it becomes very small indeed. The interesting thing about such ratios is that they involve a definite rhythmic progression. The same relationship is repeated in each increase of magnitude. This is much richer in its possibilities than a simple numerical ratio. We can apply the idea in the same fashion as our 1:2 and 2:3 ratios to lines, areas, or any other commensurate element in the composition (Fig. 3.4) (Scott, (1951, p.55).

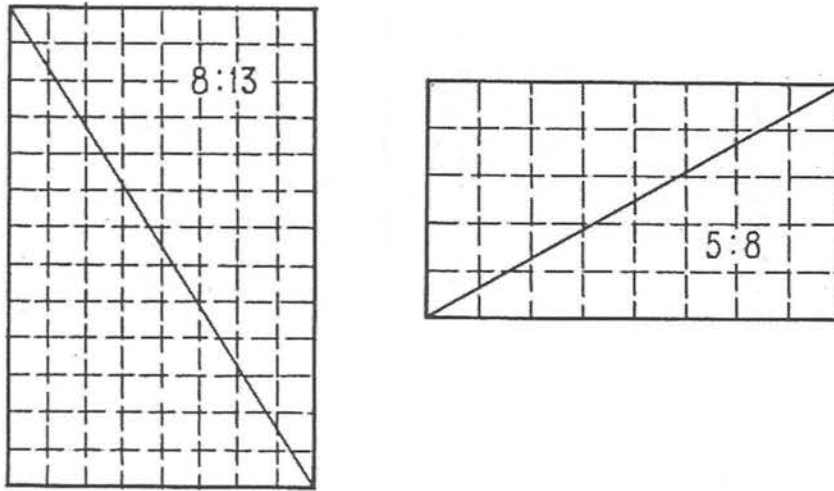


Fig. 3.4. The ratio of summation series

### 3.2.3. Golden Section

Another useful approach to analysing the ratios of muqarnas is Golden Section. It is worthwhile, however, to develop a few demonstrations of the main features. The most interesting of the muqarnas' ratios is the golden-mean rectangle, or the Golden Section. The guiding aesthetic principle of this is the mathematical proportion called the Golden Section.

The Golden Section is a way of dividing a line – or anything else – into two parts, so that the smaller part bears the same relationship to the larger as the larger does to the whole.

A unique feature of the Golden Rectangle is that it can be divided by a single line into two part one a square, the other a smaller Golden Rectangle, if successively smaller rectangles are marked off within one another, and a curving line is drawn from the end of on dividing line to the next (Breadbury, 1981, p.19) (Fig. 3.5.).

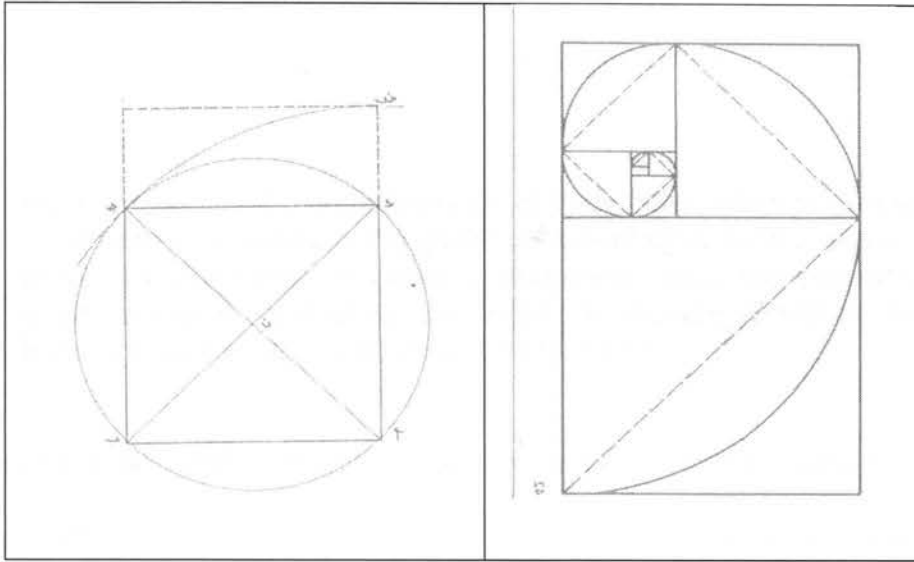


Fig. 3.5. Golden Section

Islamic architects are concerned with a unique characteristic, whether in religious or in civic architecture, namely, that it must serve the Muslim community. This reflects the essence of their beliefs, as those beliefs themselves are concerned with a non-representative and abstract form of God. This means that it is a corruption of the godly creed if such a form is subject to any description or similarity to God Almighty, as is indicated by: “There is nothing whatever like unto him” (The Holy *Qur’ān*: 42:11). There is no similarity whatsoever between God and His creation in essence, in attributes or in deed. Therefore, God is just, timeless and placeless. Thus the aesthetic relations for architecture indicate engineering quality and numerical quantity searching for that absolute aesthetic aspect in the universe, so that it can be felt as a proportional system that contains the entire building, including the contents

of the architectural elements. Researchers have been concerned with establishing and investigating this proportional content on which Islamic architecture is mainly based. The *Ikwan al-Saffa* (Epistles of the Brethren of Purity)<sup>i</sup>, through their sources (epistles) that look at the essence of proportional Islamic architecture, are considered most relevant for such purposes. As stated in the explanation of the proportions:

Be informed that the proportions are of three types, either according to the quantity, according to the quality or according to both of them. The proportional quantity is called a numerical ratio, the proportional quality is called engineering ratio, while the mixture of both is said to have a musical synthesis (al-Zrkaly, 1928, p.183).<sup>ii</sup>

The use of proportions in an artwork they considered to be: “the finest manufactures and perfected composures and the best inventions which its structure and the formation of its parts are according to the ideal ratios; the ideal ratios are: one to one; one to one and half; one to one and one third; one to one and quarter; one to one and one eighth” (al-Zrkaly, 1928, p.183). This means that the ratios are = 1:1; 1:1.5; 1:1.33; 1:1.25; 1: 1.125. These ratios are acceptable to Islamic tastes given that they reflect the proportions of the human body. The aforementioned epistles of *Ikhwan al-Safa* discuss these proportions through the image and structure of the human body. They carefully note the details of proportionality between all the body parts: “For example, His Majesty (the GOD) makes the height of human bulk proportionally fit with the length of the backbone ... etc.” (al-Zrkaly, 1928, p.166). This can be reflected on and considered for every single part of the human body. He (God) indicates that: “We have indeed created man in the best of moulds” (The Holy Qur’ān 95: 4).

The Brethren of Purity also gave another typical example of ratios in the body of a baby, saying: “where the young are born with the finest structure form, and the nicest picture due to the fact that their pure raw rank is still unaffected by artificiality” (al-Zrkaly, 1928, p.168). They examined those divine standard measures that govern a baby’s body and limbs. They also discovered an interesting relationship of proportionality between the size of his/her span and each limb of his/her body. They say in their epistle V:

If the baby was born in a perfect form, his tall body length would be eight spans. If he stretches his arms widely open like a bird’s wings, the distance between the tips of the fingers of either hand would be also eight spans. The half of that would be the span measure of his clavicle collarbone, a quarter of that until his elbows. If he puts his hands above his head and the tip of a compass divider has been put on his belly button, and opened to reach the end of his fingers, then turned around to reach the end of his toes; the distance between the two ends would be ten spans plus the quarter of his height (al-Zrkaly, 1928, p.167).

These proportions were used by Muslims and applied in their architectural works, in order to achieve the most beautiful and perfect ratios. These perfect ratios were taken into consideration precisely within the proportions of the finest architectural details, such as in vault arches, domes, capitals, windows, portals, minarets, mihrabs, minbars, façades and muqarnas. Thus these proportions were taken as aesthetic aspects that originally derived from the human body created by God Almighty, which are most appropriate and suitable for one’s sense of taste (Hamouda, 1990).

These proportions, inspired by those of the human body, later became the basis for a series of boundaries of the ‘modeller’. Farid Shafī states that “the ancient Arab Muslim architects were fully aware of the major tools and instruments for



performing engineering works such as a set angle, ruler, compass and protractor” (Shafi, 1970, p.165). It might be the case that at that particular period of Islamic history, the technical skills and abilities of professional workers meant that they could develop the initial sketches of a building and its constructional basis, and then cut out the proper sculpture in granite and marble, or, in the case of the muqarnas vault, put them together in wonderful formative matrices, and add other architectural elements, according to their professional intuitive perceptions and their technical creative imagination.

The mosque, the place where prayers are performed, is considered the principal religious symbol. It should, preferably, be rectangular in shape, and the longer side should face the *Qebla* (the prayer direction) in order to allow for the longest rows possible when praying. Thus the proportions of the mosque can be estimated as 2:1. Generally, mosques can also have open courtyards as part of the overall structure, to be used for prayer when needed. Thus the area of the courtyard should not be less than half (0.5) of the area of a small mosque or one third (0.33) of the area of a big mosque (Hazem, 1999).

Therefore, the objective mathematical approach to the numerical and engineering aspects becomes a means to achieve aesthetic beauty in architectural and artistic works in particular and permits proportionality between the dimensions, and thus achieves a general consensus. At the same time, it identifies the main parts of the building and bestows on the work as a whole a well-balanced, proportional,

measured unity. In other words, quantitative and qualitative aesthetic foundations are very important in Islamic architectural works.

Yet further proportional foundations can also be derived from these comprehensive proportions and through the relationship between the whole and the parts. Thus, it is impossible for the comprehensive proportions of a building to be determined unless its architectural constituent elements also reflect a proportionality such that all the elements are unified with the entire building. In light of the above, it will be interesting to examine the proportions of the architectural elements that are closely tied to the muqarnas, to discover their aesthetic significance, which is based upon those elements, in order to achieve the main objective of the research. The author will begin with a general study of building proportions, and will follow this with a specific study of the architectural elements and their relations to the muqarnas.

### **3.3. The proportions of religious buildings**

Islamic architecture has a unique character that is determined by the association between appropriate measurements and ratios for functional purposes, and man's achievements and his respect for entities, his feeling of belonging, and with an increasing focus also on aesthetic aspects. All this has provided a kind of honesty and purity in the expression of the main function and in the nature of construction materials and the use of obvious and hidden elements in the formation of a building. For a Muslim artist, aestheticism becomes an end in itself rather than a means. Thus their buildings reflect, to a large extent, the professional obligation to preserve the nature and rule of measurement in formative architectural structures and in the

relationship of the whole building to its internal and external space (Fig. 3.65). It also reflects the extent of the perseverance of the principle of ratios and proportionality, which are used in Islamic architecture and hence which are acceptable to Islamic taste such as: 1:2, 1:1.5, 1:1.33, 1:1.25.

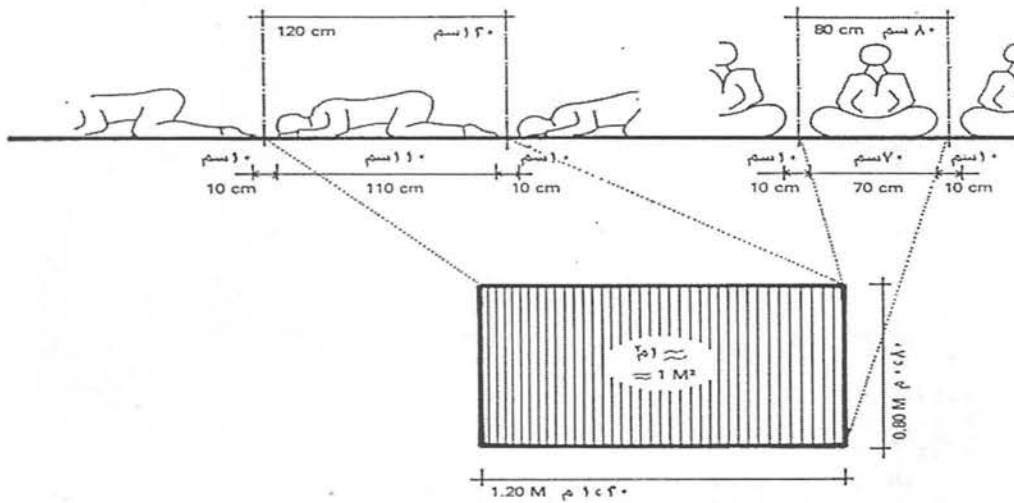


Fig. 3.6. Space Requirement for a prayer in the mosque

The epistles of *Ikhwan al-Safa* discuss these proportions, as: “the finest manufactures and perfected composites and the best inventions which its structure and the formation of its parts are according to the ideal ratios; the ideal ratios are: one to one; one to one and half; one to one and one third; one to one and quarter; one to one and one eighth” (al-Zrkaly, 1928, p. 183). Muslim architects “have applied these ratios in their architectural works to achieve the most perfect and ideal proportionality” (Hamouda, 1990, p. 156). For example, the author found that the horizontal section of the *Sultan Hassan Mosque*, built in Egypt in AD 1356, (Fig 3.7), has a length of 150 m, a width of 78 m, a height of 37 m, giving a total area of 7900 m<sup>2</sup>. (The height

of the entrance including the above-decoration of muqarnas = 37.80 m). By examining the ratios of this section, the author found that a range of ideal ratios existed: 1:1, 1:1.25, 1:1.125.

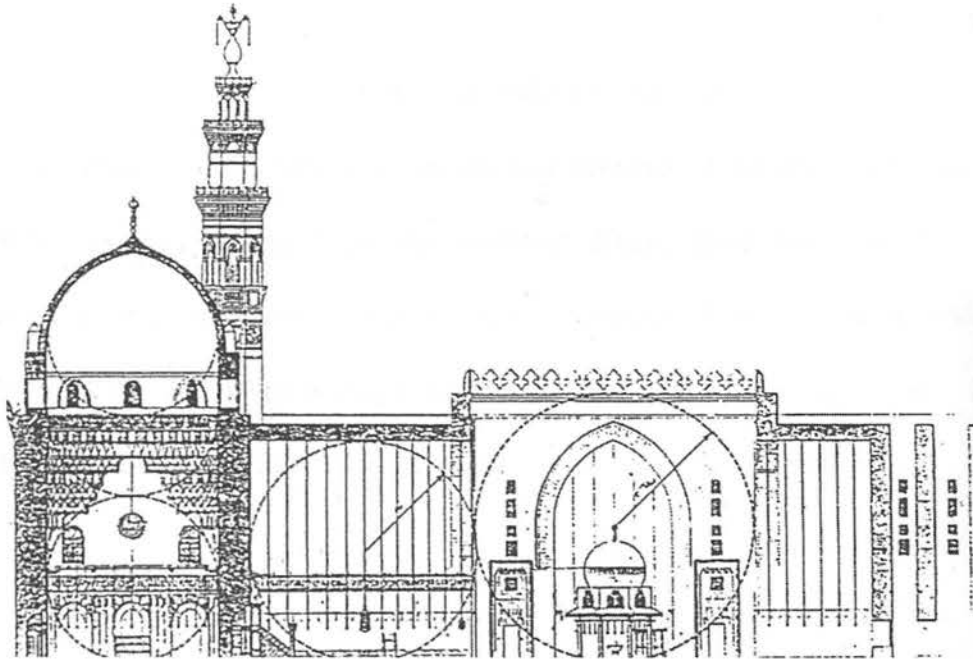


Fig 3.7. The proportions of Sultan Hassan Mosque

Harmony is achieved via the proportions of the components and the part-whole relationship. Also, the horizontal section of the *Sultan Hassan Mosque* shows that it has been subject to a range of ideal ratios, in order to achieve a harmony between the three sides of the mosque in terms of latitude, longitude and altitude.

In another example, the horizontal section of the *Shah Zada Mosque* (AD 1543), in Istanbul, in Turkey, that belongs to the Ottoman period, was found to have been subject to a range of ideal ratios: 1: 1, 1: 1.33, 1: 1.125, drawing attention to the

internal void including the domes, in accordance with the entire void unit of the whole construction.

Studies of the proportions of cross-sections of the *Shah Zada Mosque*, (1: 1, 1: 1.25), and the like, as well as of the *al-Solaimaniya Mosque* (AD 1550) in Istanbul, which were influenced by the structure of *Ayah Sofia* and the *Sultan Selim II Mosque* (AD 1570) in Edrna, Turkey, show that the internal structure of the domes of these three different mosques, designed by the architect *Sinan*, were based on two main elements, namely, elegance and proportional harmony (length 75 m, width 19 m, height 6.92 m), and were distinguished by having one large major dome in the middle, flanked by smaller domes, out of which emerged a half small dome.

The ratio of the length to width =  $75 \div 19 = 3.94\text{m}$ . i.e. 1: 4  $\approx$

The ratio of length to height =  $75 \div 6.92 = 11.5\text{m}$ . i.e. 1: 12  $\approx$

The ratio of width to height =  $19 \div 6.92 = 2.74\text{m}$ . i.e. 1: 3  $\approx$

As for the mosque of *Sultan Ahmed I* (AD 1609), in Istanbul, Turkey, the horizontal dimensions of its projection are: 64 m  $\times$  72 m, which is a rectangular form and the proportion of the length to the width is 1: 1.125, thus the ratios of its cross-section also reflect the same ideal proportions, namely, 1: 1, 1: 1.25, 1.33: 1, and so forth.

An examination of further examples of religious buildings reveals similar proportions. For instance the *al-Azhar Mosque*, built in Cairo in AD 970, has a total length of 75 m, width 69 m, and height 6.92 m, ratios of 1: 1, 1: 1.33, etc. The

architectural examination of *Sultan al-Zāhir Baroque Mosque*, in Cairo, Egypt, built in AD 1383 in the Circassian Mamluke period, shows that the proportions of the main cross-sections reflect the ratio of height to width, 1: 3, whereas the ratio of the main hall to its height is 1: 1.5. The study of the architectural spaces and the design of the complex of the *Sultan al-Manṣūr Qalāwūn*, built in AD 1334 in Cairo, reveals that the ratios used were 1: 1, 1: 1.5, 1.33: 1, 1: 2, 1: 2.25, 1: 2.5, 1: 3...etc. (Fig. 3.8).

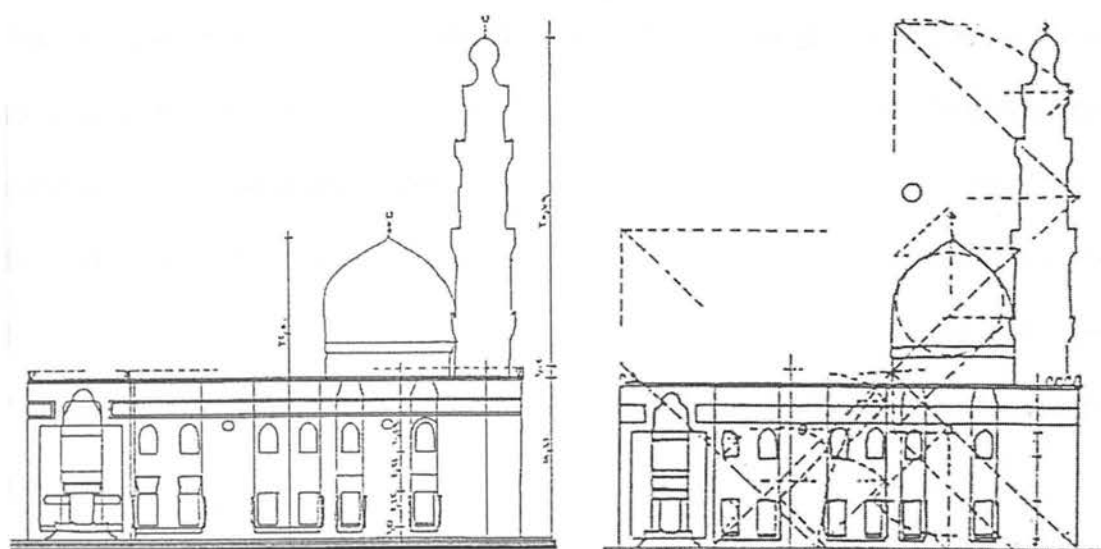


Fig. 3.8. The proportions of Sultan Baroque Mosque.

Besides the use of aesthetic principles adopted from Greek and Byzantine art, together with Pythagorean and Aristotelian theories, as well as the golden rectangle theory, Islamic religious buildings and their proportional systems in various parts of the Islamic world have perfectly met their mandatory function.

### **3.4. The proportions in architectural elements**

Architectural elements have received considerable attention within various types of buildings, thus their forms and proportions reflect a wide range of different styles in terms of their relationship to the muqarnas. This study will focus on the following elements: arches, capitals, domes, mihrabs and minarets.

#### **3.4.1. Arches**

The muqarnas in arches is a curved structure used as a support over an open space or as a semicircular opening in a wall. It can also be a self-supporting structure dependent for its structural stability and as an ornamental frame of projecting niches in a wall, or supporting structure. The study of the proportions of arches are the foundation for the study of any related proportions through the unit of the muqarnas. The author will examine four types of arches, as follows: the round arch; the pointed arch; the horseshoe arch.

##### **3.4.1.1. The round arch**

The round arch comprises one central point that consists of two identical arches that extend from the top with two straight vertical lines. The intrados arch of the muqarnas starts from top to bottom and ends in an inner side at the foot of the arch with a cascade of stalactites. These are developmental extensions of those minor elements in the shape of small stalactite vaulted arches, known as 'scallop' (Farīd, 1977, p. 199) or cusps of a curved arch. Since a curved arch is an architectural element that depends on two central axial points, "the muqarnas too depends on two central axial points" (Ghalip, 1997, p. 275). The link between the muqarnas and the

arch is a proportional connection with measurable engineering (qualitative) and numerical (quantitative) indications that identify the absolute aesthetics that contribute to the formation of the system, both in the arch as a whole and in the forms of the muqarnas within its elegance and ornamental decoration. The types of proportional ratios of arches differ from one construction site to another.

The author compared the round arches of the same construction of the *Qairouan Great Mosque* (AD 1294) in Tunisia to the arches of the *Holy Mosque (al-Haram al-Sharif)*, from the 16<sup>th</sup> century in Makkah the Great, in Saudi Arabia.<sup>iii</sup> He found that in the *Qairouan Great Mosque*, the total length is 126 m, the width is 77 m, the span between the two feet of the arch is 4.83 m, and the height of the arch is 9.15 m, (Abulgawad, 1970, p.85), while for the arches of the same construction in the *Holy Mosque - al-masjed al-Haram -* in Makkah the span between the two feet of the arch is 3.18 m, and the height is 9.5m (Fig. 3.9) (Nazif, 1989, p.200). The proportional ratios between the two feet of the arch and its height equal the total height ÷ the span between the two feet of the round arch.



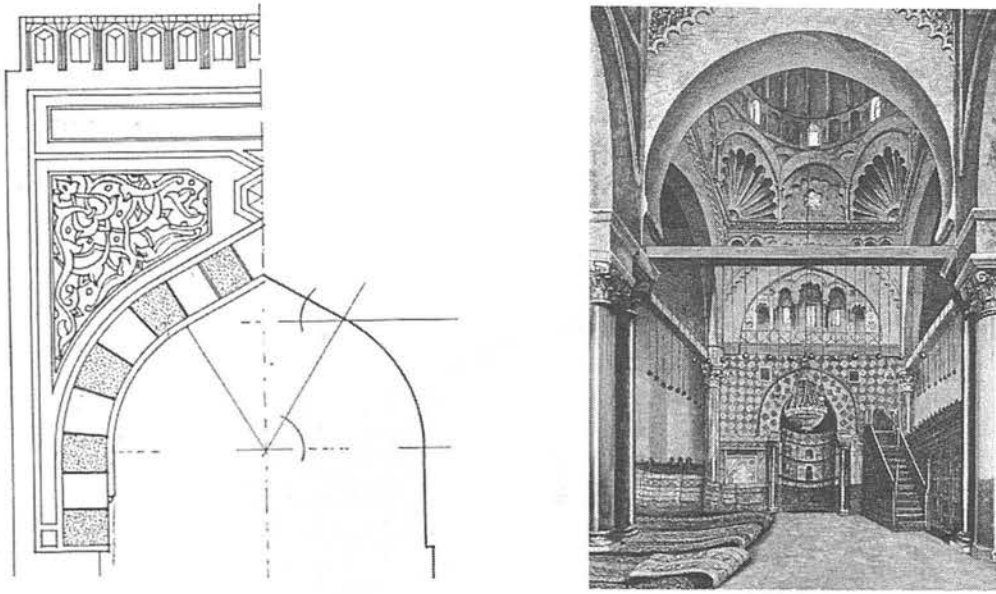


Fig. 3.9. The Holy Mosque Arch, in Makkah and Qairouan Arch, in Tunisia

The ratio of the arch of the *Qairouan Mosque* to the height of the column

$$= 9.15 \div 4.83 = 1.894 = 2 \approx$$

$\therefore$  the proportional ratio of this construction is = 1: 2

The ratio of the arch of the *Holy Mosque* to the height of the column

$$= 9.5 \div 3.18 = 2.987 = 3 \approx$$

$\therefore$  the proportional ratio of this construction is = 1: 3

This simple calculation reveals the different ratios between the proportions of the round arches of the *Qairouan Mosque* in Tunisia and the *Holy Mosque* in Makkah. These differences are related to the design-proportional ratios of the other elements that form the system. It goes without saying that different ratios of the muqarnas of the intrados arch lead to different ratios from one design to another. So the study of the proportional ratios of the round arches is deemed to be the foundation for the

study of the proportional ratios that are related to the unity of the muqarnas (Fig. 3.10).

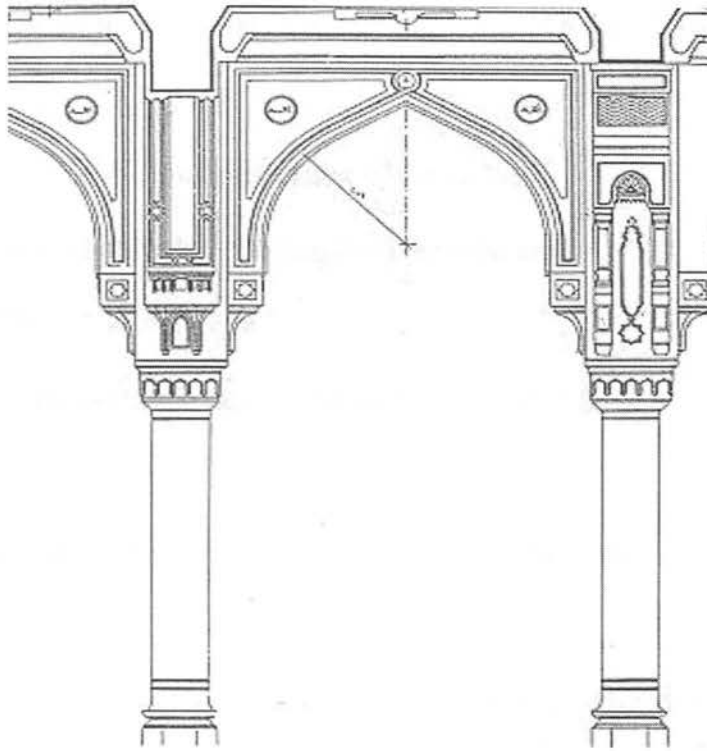


Fig. 3.10. Arch in the Holy Mosque in Makkah

The span between the two feet of the round arches of the *Holy Mosque* is 3.18 m, and the curving of the arch is 3.08 m. In order to determine the two curves of the arch, both curves have been identified on the straight horizontal of the centre, and then they continue upward towards the line within the limits of an angle of 60 degrees, and the curving is completed by extending two diagonal lines at an angle of 30 degrees. Until they meet up with the vertical axis, the two curves of the arches continue to go vertically, sloping from the central line of the span which is 0.7 m, whereas the dimensions of the span between the centre and the curve of the arch is 1.59 m.

Therefore, the height of the total arch

= the span of the curved arch from a centre + the span of the feet of the sliding arch =  $3.08 + 0.70 = 3.78$  m.

Therefore, the total proportion of the arch

= the total altitude ÷ the length of the total arch

=  $3.78 \div 3.18 = 1.18$  m.

∴ the proportional ratio of the arch =  $1 : 1.18 \approx 1 : 1$

The span between the ground and height of the arch

=  $9.5 - 3.78 = 5.72$  m.

Therefore, the proportional ratio of the altitude of the arch

= the total altitude ÷ the altitude of the arch =  $9.5 \div 5.72 = 1.66$  m.

∴ the proportional ratio of the altitude to the arch =  $1 : 1.66 \approx 1 : 2$

#### 3.4.1.2. The pointed arch

The pointed arch has a double-centred point (a and b), then two horizontal lines are drawn out of those two centres. From out of those two centres there also emerge two lines at an angle of 60 degrees. Thus one can draw the curvature of the arch so that its two ends meet up with the horizontal line as well as the line of the 60 degree angle. There is another sloping line at an angle of 30 degrees to reach the axial point of the pointed arch (Fig. 3.11).

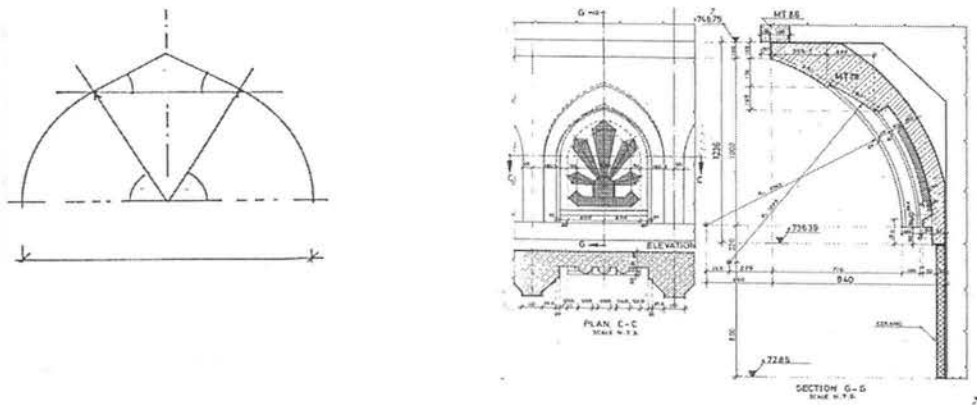


Fig. 3.11. The axial point of the pointed arch in each muqarnas

This gives a pointed arch at the bottom of the two curvatures against the two horizontal straight lines, which, when extended, completes the vertical line, to get the appropriate length for the arch. From this simple calculation of the pointed arch in the *Holy Mosque* in Makkah there is much to learn: the span between the two the centres of the arch is 1.88 m, the span between the centres and the curvature of the arch is 0.43 m, the height of the double-centred point of the pointed arch is 1.05 m, the span between the centre and the foot of the arch is 0.72 m, the length of the arch is 2.74 m and the total height of the arch is 1.77 m.

Therefore, the overall proportional ratios

= length of the arch ÷ height of the arch

=  $2.74 \div 1.77 = 1.548 \text{ m} \approx 1: 1.5$

∴ The proportional ratios of the pointed arch  $\approx 1: 1.5$ .

From these proportional ratios of the round arch and the pointed arch, it can be argued that the design of both arches reflects the ratios that are referred to in the epistles of *Ikhwan al-Safa*, which discusses the proportions that the Muslim artist should apply in any architectural design.

### 3.4.1.3. The horseshoe arch

The horseshoe arch is based on the semi-circular arch and is a characteristic of Islamic architecture in western regions. This type is also known in the eastern regions but the arch is less transcended, semi-circular and is often broken. The horseshoe arch has different scales, proportions and ratios between the diameter and the height; ratios of 4: 5 are found, but the usual ratios is 3: 4. "This is because the recent measurements are considered more aesthetic" (Ghalip, 1988, p.281).

The horseshoe arch appeared in the west region of Arab-Islamic buildings, and many examples can be found in Moroccan and Andalusian architecture, where they have adopted the horseshoe arch and decorated it with many types of muqarnas, constructed in various materials, such as stone, gypsum and wood. Admirable examples of this arch can be found in the *Madīnat al-Zahrā' Palace*, built in AD 936–76 in Cordoba, Spain. There are examples too in the *Alhambra Palace*, from the 13<sup>th</sup> and 14<sup>th</sup> centuries in Granada, Spain; in the *Karawiyyin Mosque*, built in AD 856 and in *all-Tarin* madrasa (school) (AD 1323), both in Fez, Morocco.

However, the horseshoe arch has not always kept the shape of a horseshoe, as the cascade of stalactites have controlled a muqarnas, where the small vaulted arch

protrudes from the intrados or the extrados or the basis and the footing of the horseshoe arch. Thus the proportional ratios of the muqarnas represent approximately 1: 3 and 3: 4. Accordingly, the ratios reflect the relationship of the muqarnas to the building, and adhere consistently to the proportional ratios that are referred to in the epistles of *Ikhwan al-Safa*.

#### 3.4.1.4. The composite arch of muqarnas

The composite arch is supported by a pointed and a round arch, constructed from concave composite muqarnas and prismatic composite muqarnas. They are curved by stalactites vaulted in the intrados arch, which begin with one muqarnas from the upper part of the arch and move downwards on either side (right and left) towards the feet of the end of these arches. The composite arches are similar to the 'lobes arch' where the muqarnas looks like semi-circular (mini half-dome) cascades from an intrados arch (Ghalip, 1988). They are constructed with arches in the middle, with arches in the ending of these arches, which are side by side and the tail of those arches fills the empty space. Examples can be found in the *Alhambra Palace*, in Granada, from the 13<sup>th</sup> and 14<sup>th</sup> centuries and in the mosque of *Sultan Hassan*, in Cairo (AD 1356–61).

The unique technical achievement, with its proportional ratios of the rows of muqarnas in the intrados arch, reflects an aesthetic value as it is linked within an organised system of coordinates, creating a divisional overlap of the harmonious, in accordance with the unit of the muqarnas within the intrados arch, which has fixed proportions.

As for the suspended arch of the muqarnas, it differs from the composite arch in that the former takes the form of one single row, ending with a semi-circle at the foot of the suspended arch of the muqarnas, whereas the composite arch has a gradual downward slope. The suspended arch is usually used for higher recesses in walls and in the main gateways (portals) of some mosques, houses, etc. In an examination by the author of the outward façade of one of the houses in Cairo which contains some suspended arches, the proportional ratios of the suspended arches were revealed as: 1: 1, 1: 1.5, 1: 1.33, 1: 1.25.

This shows that the Muslim artist uses the aesthetic proportional ratios inspired by the fixed proportions of the human body created by God Almighty because they are found to be the most suitable, appropriate and satisfactory to Islamic taste.

### 3.4.2. Capitals

The Islamic masons and artisans were innovative in terms of the heads or upper parts of a column, which were carved with muqarnas decoration. The muqarnas capitals are decorated with one, two or three superimposed rows of carved shafts on a column or pier, and a beam, arch, or vault around the capital. Examples of muqarnas capitals can be found in the portal of the *al-Sultan Hassan Mosque* (AD 1356) in Cairo (Lami, 1986, p. 78), and in the capital of the marble mihrab columns of *al-Muäyyad Shaykh* (AD 1420), also in Cairo (Abdulwahab, 1946, p. 96). The most striking example of a muqarnas capital is to be found in the columns of the *Alhambra Palace*, of 13<sup>th</sup>–14<sup>th</sup> centuries, in Granada in Spain. Other examples have been found in

Ottoman buildings, such as in the *Süleymaniye Mosque* (AD 1550–7), and the *Sultan Ahmet Mosque* (AD 1609) in Istanbul (Abdulwahab, 1946) and in the columns of the *Holy Mosque (al-Haram al-Sharif)*, from the 16<sup>th</sup> century in Makkah the Great, in Saudi Arabia, and the Prophet's Mosque in Medina.

The columns that were formed by Arab-Islamic masons and the skilled creators of Islamic architecture are distinguished by their Eastern and Arab traditional forms, typified by their elegant simplicity. Thus their proportion in relation to their height is 12 times the diameter. "They have very fine-looking capitals of tall shafts and square bases that were carved at the head or upper part of a column by a muqarnas decoration" (Abdulgawad, 1970, p. 148).

The link between a capital and a muqarnas is related to proportions and measurements that are qualitative and quantitative, and are indications that identify the absolute aesthetics that contribute to the formation of the system in its entirety. The proportional relationship between a capital and a muqarnas can be found in the example of the capital of the muqarnas in the *Holy Mosque* in Makkah (Fig. 3.12).



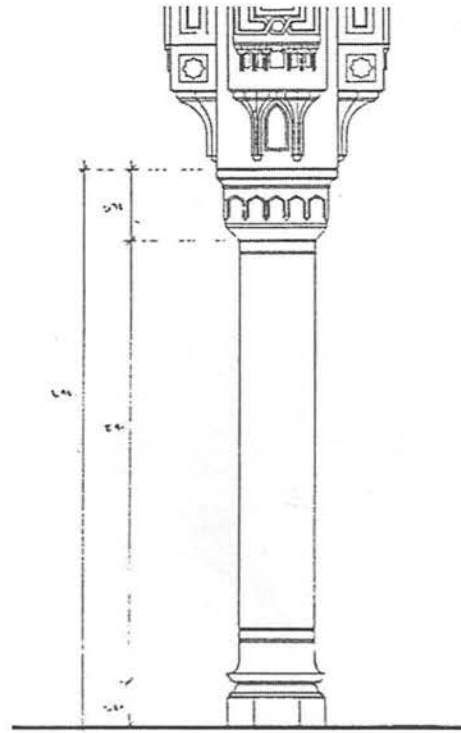


Fig. 3.12. Column with muqarnas capital in the *Holy Mosque* in Makkah

The proportional ratio between the length of column and the height of the capital

= the length of the total column  $\div$  the height of the capital

$$= 4.94 \div 0.64 = 7.71 = 8$$

Therefore, the proportional ratios of the height of the column to the length of the column capital = 1: 3

$$(2 + 6 = 8) \text{ and } 1 \times 2 = 2$$

$$3 \times 2 = 6$$

$$\therefore 2: 6 = 1: 3$$

By studying the capital of the muqarnas in the frustum of a pyramidal capital with square outer form to circular inner form (Fig. 3.13), the author found that the proportion of the one row of muqarnas to the capital was  $\approx 1:3$ .

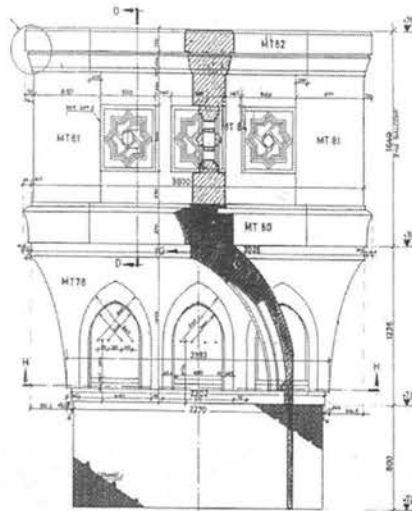


Fig. 3.13. Capital of the muqarnas in the *Holy Mosque* in Makkah

From this the author concludes that the two figures reflect the significance of the relationship between a single column, the capital and muqarnas. These ratios are in line with those referred to by the Muslim artist, who has applied those proportional ratios in architectural designs.

### 3.4.3. Domes

Domes are considered highly relevant elements to muqarnas, as the Muslim artist often used adornments and decoration with muqarnas, as can be found in the domes of the Seljuk, Mamluke, Andalusian and Ottoman reigns all over the Islamic world (see 2.5. generative unite of the muqarnas in chapter two).

The study of the proportional ratios of the dome is a foundation for its related proportions through the unity of the muqarnas. Perhaps the highest point of this architectural concept can be verified in the *Alhambra Palace* in Granada, in the dome of the Two Sisters Hall (Fig. 3.14), and from ancient times, in the domes of the tomb of *Imām Dūr* (AD 1085), in Samarra (Fig. 2.16 ) and the tomb of *Sitta Zubayda*, from the late Abbasid period (AD 1179–1225), both in Iraq. Other examples of muqarnas domes can be found in Egypt from the thirteenth century, in the mausoleum of *Shajarat al-Durr* (AD 1250) and in the dome of the *Imām Al-Shāfiʿī Mosque* from AD 1211.

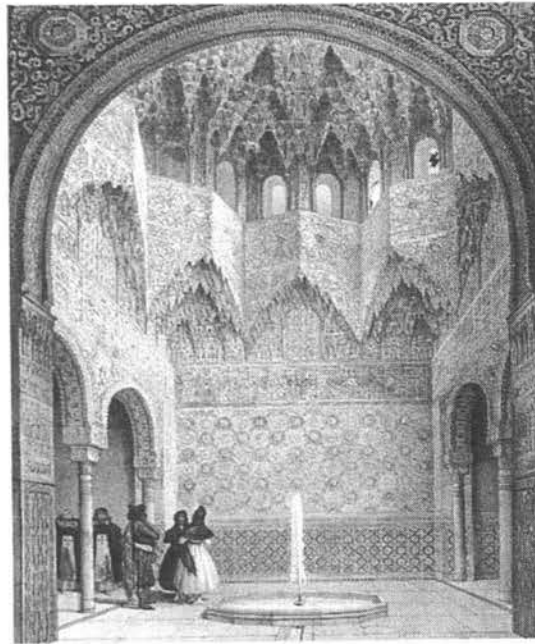


Fig. 3.14. The dome of the Two Sisters Hall in the *Alhambra Palace* in Granada

The idea of muqarnas is related to the emergence of the dome, as transitional zone between the square shape of the room and the circular shape of the dome, for use in order to hide the hard edge. Islamic architects used the proportional ratios in the

formation of domes and also applied them in their architectural designs, in order to achieve the best proportionality that was possible.

In an analysis of the dome of Sultan *Faraj Ibn-Barqūuqe Mosque*, built in AD 1401, in the Circassian Mamluks period, the main ratios of the mosque heights with the other architectural elements are 1: 3 (Emin, 1987). In the inner of the dome have six rows of muqarnas, which the proportional ratios is three time of the height of those muqarnas rows to the length of the dome. By studying the six rows of the muqarnas in the top of the circle of the dome, and the bottom of the square of the room, the author found that the ratio between the muqarnas rows and the lantern of the dome  $\approx$  1: 3. The conclusion can be made that both proportions reflect the value of the relationship between the muqarnas and the dome (Fig. 3.15).

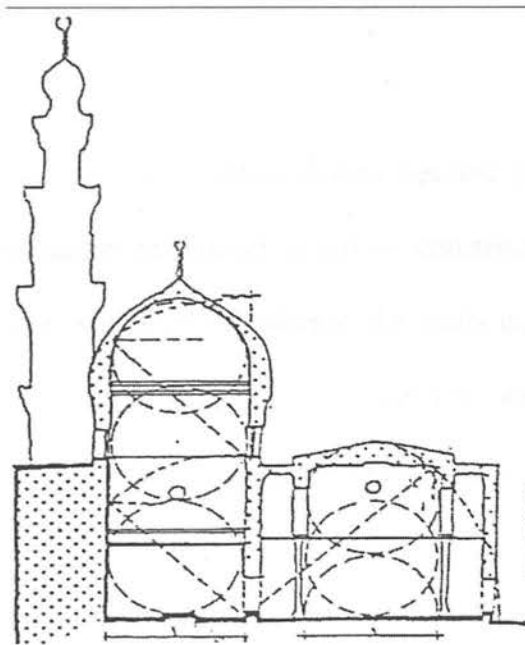


Fig. 3.15. The proportional of dome of Sultan Barqūuqe Mosque

As Ottoman architecture has shown, the idea of designing domes prevailed in architecture worldwide and within the considerable architecture of the Islamic empire, including the Seljuk architecture in the Mesopotamian region, the Mamluks architecture in Egypt, and the massive mosques in Iran, central Asia, India and Turkey and other traditional buildings of their predecessors. Thus in these buildings, the construction of domes with cosmopolitan features becomes an indistinguishable characteristic of religious buildings. The courtyard of the mosque is usually rectangular in shape, open to the sky, and is surrounded by corridors on four quarters. These small domes are square based. Being towards the *Qebla* direction, however, the main hallway in the fourth direction has more importance as a vestibule, making it a great space, covered by a large high dome in the centre, supported by four large spherical triangles based on four huge pillars made up from semi-domes and a number of other smaller domes.

In fact, it is at this stage of history when domes become the basic element that represents Islamic character in its formation and its constructional systems, which connect the interior spaces squeezed in between the walls by filling them up with three-dimensional adornments and decorations. This is done with the proper selection of heights that are proportionate with the surface of the interior spaces.

By studying the projection sector for different domes in Turkey, in the Ottoman period, for instance, the dome of the complex of *Şehzade Mehmet*, mid-16<sup>th</sup> century, in Istanbul and the dome of the complex of *Sokollu Mehmet Paşa*, from AD 1572 in

Istanbul, and the dome of the complex of *Selimiye*, from AD 1569–75 in Edirne, it is evident that all their ratios are approximately 1: 1, 1: 1.5, 1: 2, 1: 2.5, 1: 3.

The author found that ratio of the rows of the muqarnas to the dome was Approximate  $\approx 1: 3$ .

He found too that the proportional ratio between the muqarnas rows, and the lantern of the inner dome and the corner form of the square of the room represents:

$$1: 3 - 1: 1 \approx$$

He concluded that both ratios of the rows of muqarnas and domes reflect the significance of the integration of space and the value of the theme of unity, which is a relationship between a single muqarnas and the dome. These ratios are in line with those referred to in the epistles of *Ikhwan al-Safa*.

#### 3.4.4. Mihrabs

The mihrab is a relevant element to the muqarnas, as the Muslim artist often made it an entity of adornment and decoration, as in Iranian, Mesopotamian, Egyptian and Turkish mosques. As a result, studies of the proportional ratios of the mihrab can be taken as the foundation for the relevant study of the proportional ratios of the muqarnas unity.

A mihrab can come in various shapes (flat, semicircular, polygonal, rectangular, etc.) According to vertical projection, and they are usually ornately decorated (Encyclopaedia Britannica, 2008), with geometric or foliated sculpture or tiles or

muqarnas vaults. The top of the extrados of the mihrab is usually a rounded or a pointed arch, and the top of the intrados of the mihrab:

Is a semi-domed or concave niche that is recessed in a wall and adorned with pillars or with a band of muqarnas decoration, which was Seljuk innovation in Anatolia, in the central Asia. (Rihawi, 1990, p.164).

Thereafter, the type of concave niche in a semicircular spread, consisting of inner decoration with various rows of muqarnas (Shafi, 1970, p. 154) was widely used in Ottoman architecture, even becoming the main style and form in that period. This style is represented in different models (see 2.7.7. Mihrabs examples in Chapter 2).

By studying the vertical, horizontal and cross-sections of the *Acialki Mosque*, or *al-Kha'ci'alki* mihrab<sup>iv</sup> from AD 762 in the second Abbasid Caliph al-Mansūr, in Iraq (Ghalib, 1988, p. 325), the following proportional ratios emerged: 1: 1, 1: 1.5, 1: 1.33, 1: 1.25, 1: 1.125. In addition, a study of the mihrab of muqarnas in the *Ash'kali Khan Mosque*, from AD 1249, in Avenue, which has a polygonal-shaped mihrab with five tiers of muqarnas, in a concave niche recess in the wall provided the following proportional ratios: 1: 1, 1: 3.

Therefore, the author has concluded that both mihrab ratios (*al-Kha'ci'alki* and *Ash'kali Khan*), as well as the positions of the muqarnas rows, reflect the value of one linked to the relationship of the whole building, and they are consistent with the ratios referred to, in order to achieve the most perfect proportionality even at the smallest scale of architectural detail (Fig. 3. 16).

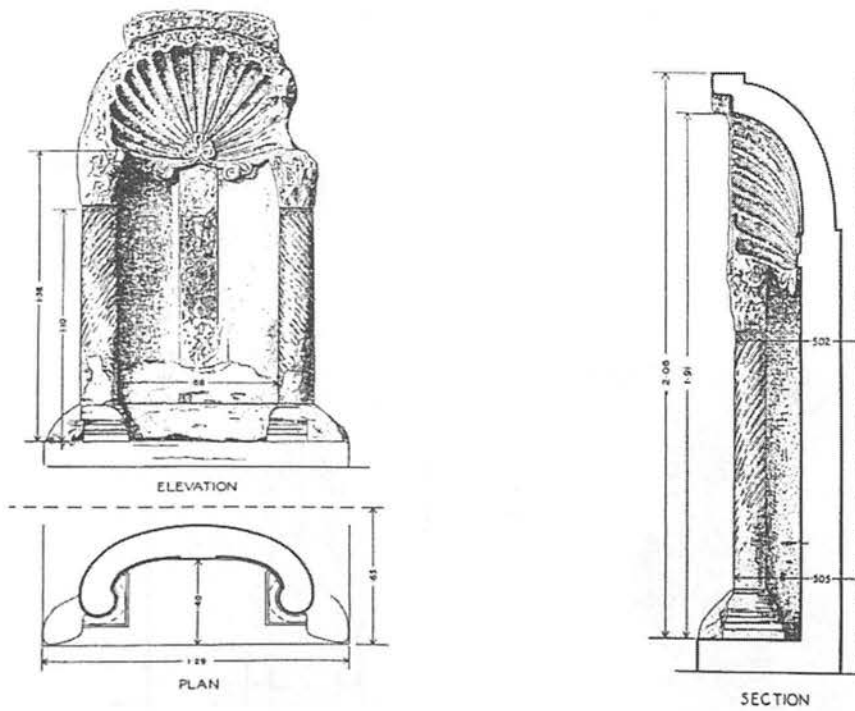


Fig. 3. 16. Mihrab of al-Kha'ci'alki

### 3.4.5. Minarets

Minarets are distinctive architectural features of Islamic mosques. They are often decorated, tall, with several floors, and are elegant with layers of a grid organised by the various rows of muqarnas. The minaret design was initially a square shape, but over the centuries it became an octagonal shape and then a circular or cylindrical shape. Mosques are found all over the Islamic world, and "the square minaret style is still in use today in Morocco and North Africa" (Salim, 1987, p.3). The size of minarets varies according to their form, which includes cylindrical, cubic and polygonal, and depending on their height and the number of floors. For these reasons, the study of the proportional ratios of minarets can be useful as the foundation for a relevant study of the proportional ratios of muqarnas unity.



An analysis of the minaret heights according to the principal ratios of the mosque height in terms of the other architectural elements of the *Sultan al-Ghūrī Mosque* from the Mamluk period (AD 1514), in Cairo (Emin, 1987), shows that they are: 1: 1, 1: 1.5, 1: 3 (Fig. 3.17 ).

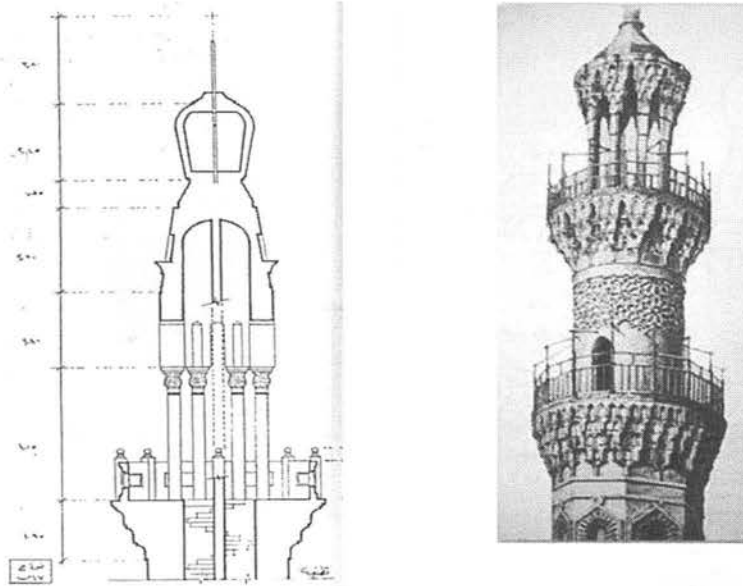


Fig. 3.17. The minaret of Sultan al-Ghūrī Mosque

A study of the sectors of the minaret of *Sultan Faraj Ibn Barqūq Mosque*, from AD 1400 in Cairo, in Egypt (Emin, 1987), which is covered with a band of muqarnas rows in the upper part between the shaft and balcony of the minaret, showed the principal ratios of the mosque height in terms of the other architectural elements to be: 1: 1, 1: 3 (Fig. 3.7).

In addition, further ratios were discovered by studying the correlation between the minaret and the muqarnas as shown in the dimensions and measurements of the model of the two of the minarets of *Sultan al-Ghūrī* and *Sultan Faraj Ibn Barqūq*

mosques, with the study of the two models (Fig. 3.18) regarding the muqarnas rows, the author has concluded that by comparing both ratios, and by studying the muqarnas unit related to two minaret, which its represents 1: 3 approximately.

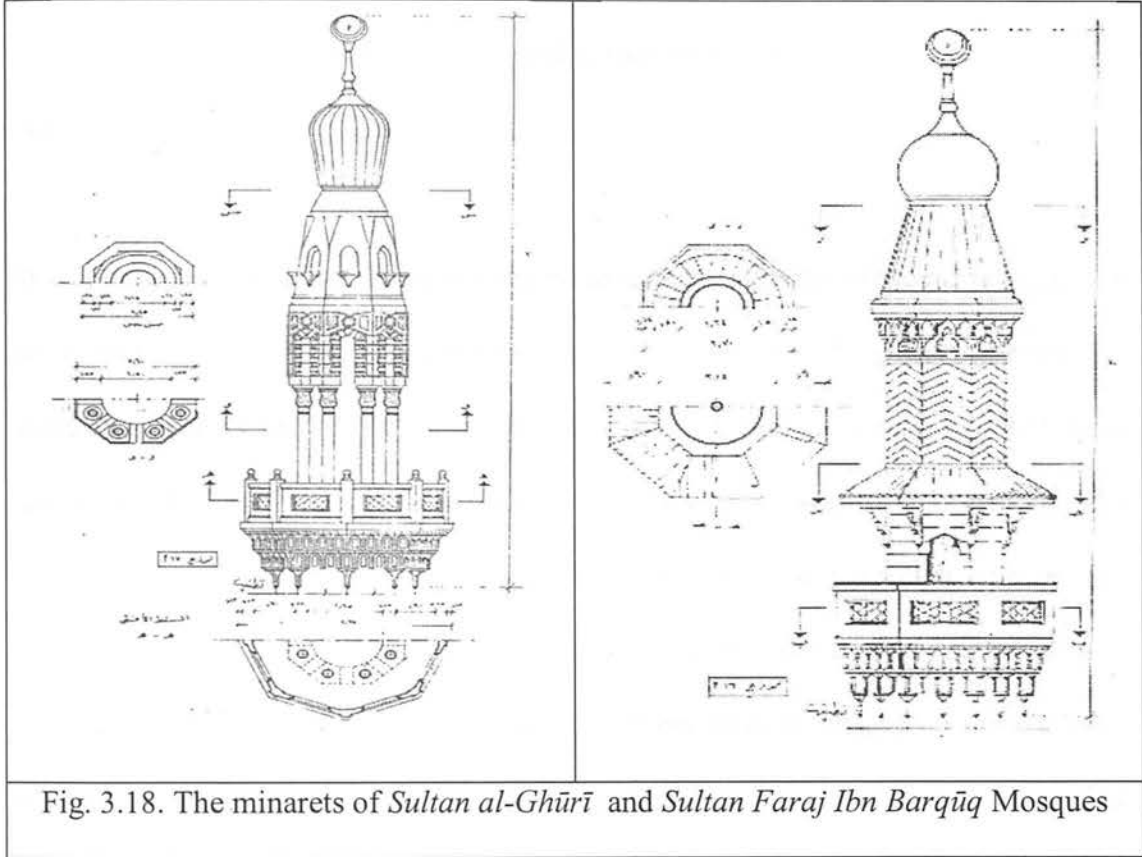


Fig. 3.18. The minarets of *Sultan al-Ghūrī* and *Sultan Faraj Ibn Barqūq* Mosques

It reflects the value of one linked to the relationship of the whole building, and is consistent with the ratios referred to, in order to achieve the most perfect proportionality, as referred to consistently in the epistles of *Ikhwan al-Safa*.

### 3.5. The creation of the muqarnas and the aesthetic aspect

Islamic architects are concerned with harmony, with applying geometry to a space and in doing so with various materials such as wood, marble, metal, ceramics, etc., whether it is in religious or in

civil architecture or whether the traditional tools of a compass and rule are employed (El-Said, 1976, p.7).

This reflects the essence of their religious beliefs, which are concerned with non-representative and abstract forms of God and are the result of human intelligence and the natural environment, linking together man's physical and spiritual needs, which appear in the creative arts indirectly and reflect the attempt to create architectural formations.

It can be argued that nature did not intend to express atheistic elements in each tree or mountain. It is man who describes it in this way, ascribing beauty from the essence of his feeling of the accord between the form and forces that worked in its composition, that is, the strength of God the creator. (It is when men in general, and architects in particular, come ever closer to God Almighty through science and knowledge in the discovery of its eternal laws, and start applying them mindfully and consciously in their architectural designs that it becomes an adjunct to the currency of the architectural form, characterised by the same resonance of honesty that characterises the whole of nature (Alwaly, 1988))

The muqarnas is considered to be an extension of geometric formations in space which assist in the transition between the square, circle and octagon. They consist of beautiful artistic components of diagonal lines for the flexure curvatures, refractions, intersections and overlapping formations. Thus, these formations of overlapping groups of muqarnas that emerged in Islamic architecture are considered to be superior formations and represent an artistic creativity that highly distinguishes the culture, specifically, the Mamluke architecture in Egypt, Persian architecture in Iran,

Ottoman architecture in Turkey, Moroccan architecture in northwest Africa and the highly creative architecture of Andalusia, as is evident in the palace of the Alhambra.

Therefore, the designs of the muqarnas vary according to their use. For example design of muqarnas in the corners differs from that of the walls, from that of the domes, from that of the capitals, from that of the columns, from that of the entrances, from that of the recess covered with niches, from that of the arches, from that of the intrados arch, from that of the mihrab, from that of the minaret.

The muqarnas is three dimensional in different geometric forms, sizes and angles, which can be seen as stalactites in the corridors, domes and portals of buildings. Thus, it has played a major role, for example in those interior in the domes – such as Chamber of the Lions and the Two Sisters Hall in the palace of Alhambra, and in the tomb of *Sultan Hassan*, in Egypt. It has inverted elements while hanging vertically downwards, defying gravity and defying visible ray system. It lookalike as the architect had left tens of stalactites flying in the sky, and also, the same as icicles hanging from the ceiling of a natural cave. Each carving of the muqarnas was corbelling, bulging-out, flat, cascading, concave, convex, surrounding lines and surrounding masses. It has exhibited light and shadow resembling magnificent elegance and sense of beauty.

The designs of the muqarnas differ, depending on their uses and the relationships between them. Thus, there is what is achieved by the aesthetic system in the external and internal vision of the whole entire building and what is achieved by other,

different parts of muqarnas arranged in an agreeable consistency, including the division and conformity of muqarnas as a unity. It is generally found under a cornice and above the bed-mould of Corinthian entablature, and at the same time, it hides the transitional zones between various surfaces (e.g. arches, domes, capitals, windows, ceilings, minarets, mihrabs, minbar, façade and a variety of furniture) and consists of a number of shapes, forms and in some circumstances resembling stalactites. which comprise consecutive cells of muqarnas arranged in harmony, either concave or convex; deeply set or protruding; and showing light and shade.

Internally, there exists the same agreeable consistency and harmonic arrangement of the different parts of the muqarnas, which creates embellishment and beauty. Again, simple geometric shapes are used, which can be presented with great diversity and vitality. For instance, consider the effect of the rows of muqarnas in the mihrab of the *Great Mosque*, in Bursa, Turkey (see Fig 2.73), where the modules are consecutive and contrasting, from the top of the mihrab, where there is one muqarnas, coming downwards, in two rows, then three, then five, then eight rows, reflecting a geometric progression, namely: 1: 2: 3: 5: 8.

Therefore, in Islamic architecture, in the creativity of composition of the muqarnas, artists are concerned with aesthetic harmony and configuration that brings together all the elements of composition and proportion, allowing the muqarnas to emerge as aesthetically interdependent formations.

In the formation of one single muqarnas (e.g. stalactites), the area will basically consist of four equal areas. However, they display different specifications, so each two opposite areas are counterparts necessary to complete the unit. So the upper layers converge in the line that represents a midway point of the unit. It is a calm move that gently gathers these two levels. Particularly, they represent the two sides of the obtuse angle. The next two areas are equal as well, according to a different sense of logic, though, as they are located midway in a layer in a lower space. These two areas, however, represent the two sides of an acute angle, and its end meets a straight line from the bottom which extends with an upward curve in arc-shapes raised gradually to meet up with the line resulting from the confluence of the two sides of the obtuse angle. These three muqarnas-like parts then end up with triangular bases in different directions. That is, the areas of these bases are triangular in shape, but with divergent levels.

However, a shadow is cast by the high surfaces is intensified, mainly through the fragmented space of this muqarnas, hence, it can be the most shadowed part of this unit. Thus, the other shadows that are generated from different degrees of incline in the surfaces are of a composed style that clashes with the shade of that space. As for the lines, there are the lines that specify the nature of the component from outside, which form a peripheral facet including a central layer, together with the edges of the above-mentioned areas. Moreover, there are also other lines that define the relationship of the spatial bases of the cascade of stalactites in relation to the other surfaces. However, we see that there is another incompatibility within this unit, one that combines the straight line and the specific arc in the same area. This single

cascade of stalactites is distinguished by the general solid area and the two-part piercing vacuum, the formation of this general solid area is controlled by the angles of inclination which, by neighbouring each other, can repeatedly furnish some areas that end up with what appears to be a refractor line. Given the domination of these areas, the author found that the Muslim artistic designer had intended to overthrow the cascade of stalactites by even longer proportional ratios than the sided layers, in order to provide a sense of space commensurate with the solid area.

### **3.6. Conclusion**

The final solution for the formative component of the muqarnas involves two clear movements, the movement of the straight line and the movement of the diagonal line (represented in the unit of the muqarnas element). The movement of force, control and pure colour belongs to the straight line whereas the movement of fine art belongs to the diagonal line. The straight line therefore is not that pretty, but the curved lines are the art.

Thus straight lines do not necessarily create art, but the overlapping lines, crossed-over lines and technical colourful shades of man's attempts to create architectural composition are what produce architectural beauty for us. It is through the correlation of these two formative movements in the vacuum of the straight line (the corner of the cubic chamber) and the diagonal line (the transformation of the square to circular and octagonal shapes) that the element of the muqarnas achieves the power and the fine art of this architectural composition. The overlap between the movement of the straight line and the movement of the diagonal line and within itself

is represented in the unit of the muqarnas element that completes the creativity through the formation of parallelism, balance, symmetry, inversion, matching, dissimilarities and indefinite repetition. It therefore matches the infinite creativity of the universe, and acts as a magnet for all at the centre and radiating from the centre, reflecting its importance as an aesthetic source in Islamic architecture.

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i - The *Rasā'il of the Ikwān al-Ṣaffā* (Epistles of the Brethren of Purity) is a unique work in Islamic history consisting of approximately fifty-two epistles (*rasa'il*) on a wide range of subjects. The original Brotherhood of Purity was a group of anonymous scholars from Basra in the tenth century who produced a compendium of arts and sciences which was published for all to read and contained a virtual condensation of all knowledge of the time. Their sympathies were with the Pythagorean-Hermetic aspect of the Greek heritage. This is especially evident in their mathematical theories, which were later to influence Shi'ite circles. The quotations are taken from *Rasā'il*, 5 vols. a version edited by Khīr al-Dīn al-Zrkālī, (rd) Egypt, in 1928 Beirut: Dar Beirut, 1957. In Arabic.

*Ikwān al-Ṣaffā*, *Rasālat* VI: On the arithmetical and geometrical proportion with respect to the refinement of the soul and the reforming of the characters, by the Brethren of Purity (4<sup>th</sup> century AH/10<sup>th</sup> century AD), Section 1, on Epistle VI: p.183.

ii - *Ikwān al-Ṣaffā*, *Rasālat* VI: On the arithmetical and geometrical proportion with respect to the refinement of the soul and the reforming of the characters, by the Brethren of Purity (4<sup>th</sup> century AH/10<sup>th</sup> century AD), Section 1, on Epistle VI: p.183.

iii - The mosque was enlarged by the Ottoman Sultan Selīm II, who, in the 16<sup>th</sup> century, gave this mosque the form it kept until the recent rebuilding by the Sa'ūdīs.

iv - Al-Khaci'alki mihrab, found in the Iraq museum, which dates back to eighth century of the second Abbasid Caliph al-Mansūr, (Ghalib, A. op. cit., p.325).





## **Chapter Four: The Muqarnas Identity and Structure**

4.1. Introduction.

4.2. Structuralism.

4.3. Deep structure and surface structure.

4.3.1. Typology.

4.3.2. Form.

4.3.3. Space.

4.3.4. Ornament.

4.3.5. Laws of composition.

4.3.6. Hierarchy.

4.3.7. Order.

4.3.8. Wholeness.

4.3.9. Transformation.

4.4. Identity.

4.5. The meaning of muqarnas.

4.6. Aesthetics and symbolism of muqarnas.

4.6.1. Social and cultural dimensions.

4.6.2. Unity.

4.6.3. Cosmology.

4.7. Conclusion Chapter Four.

#### 4.1. Introduction

The muqarnas is a three-dimensional structure, made using concave elements, which may be numerous, and which are assembled according to complex geometric rules, with a goal that is more often ornamental than structural. It has deep roots in all aspects of aesthetics and proportionality, as related in the previous chapter. The best way to understand this phenomenon is to address its connection to these various aspects, using ideas about structural transformation in Islamic art and architecture, based on structuralism, and other associated theories. This chapter starts by offering a theoretical interpretation of structuralism, and acts as an umbrella for the fundamental concepts upon which the study was developed.

The aim of this chapter is to reveal the intellectual and subjective attributes related to the muqarnas. The theories of structuralism have been used because the author has found this the best way to introduce his intention and clarify all the aspects related the muqarnas. This description will be a step towards the next stage of producing a computerised version for creating the muqarnas that retains these attributes, which are important for maintaining the function of the muqarnas, both as structure and ornamentation.

This study of the muqarnas is driven by the intention to reintroduce the classical muqarnas in a new version which suits modern needs and requirements.

Structuralism is used to gain understanding of the idea and meaning of the artefact as a major element of Islamic architecture.

However, this chapter starts by offering a theoretical interpretation of the structuralist approach, and sheds light on important intellectual aspects related to the meaning and symbolism of the muqarnas. The author will address issues of identity from the point of view of structuralism. This identity has rules based on culture, continuity, aesthetics, taste and meaning. These include the aesthetics and symbolism which arise as a result of the surface structure and its transformation of the deep structure to present its meaning. This gives rise to the claims of the study that the muqarnas' identity and structure were the result of an evolutionary process. This project aims to take this process a stage further by developing a muqarnas software program.

## **4.2. Structuralism**

The term structuralism is a theory with several interpretations, used in many contexts in different disciplines in the 20th century. It was first presented in 1929 in the social sciences as a general philosophy but it is now applied in very wide range of disciplines. This implies that no single definition applies to it, unless it is in very general terms. Therefore, it was agreed to define a structure as a system of transformation that takes place over time (Piaget and Maschler, 1971). This concept was the principle of the theory of structuralism, whose models try to create the fundamental reality that exists within the studied system (Masaud, 1996). Therefore, it is thought that structuralism is the expected progression to Systems Theory.

In other words, structuralism describes a process of transformation for the sake of enriching the system of phenomena or ideas. Structuralism proposes that many phenomena do not happen in isolation, but occur in relation to each other. It represents an entity as a whole that consists of elements, and there are relationships between these elements. The whole with its elements and internal relations defines a structure.

However, the study reviews some of the many attempts made to explain this very important concept. Abdalla (1998, p.326) explains a structure saying: "It is a complete set of relationships, in which the elements can change but in such a way that these remain dependent on the whole and their meaning". In this regard, Luchinger (1981) says that the whole is independent of its relationship to its elements. The relationships between the elements are of greater importance than the elements themselves. The elements are therefore interchangeable, unlike the relationships. Ehrmann discusses this issue and says "a structure is a combination and relation of formal elements which reveals their logical coherence within given objects of analysis" (Ehrmann, 1970, p.22). Ujam (2006)<sup>i</sup> supports the general definition that a structure is a system of transformation, by explaining that a structure consists of the same components of the system and relationships, the only additions are time and process, denying the existence of concrete elements in language or any other system. De Saussure (1966) proposes an abstraction as the unit and a formal structure as the source of systemness. Hence, the systemness of any natural, social or environmental whole may depend not only on the interaction of units within the

system, but on the history of the transformation of the system and its units, regulated by the system itself during its evolution. This issue is confirmed by Hillier and Leaman's (1973, pp. 36-37) indication that all systems should be explained by referring to their history transmitted through the structure of their units and regulated by the evolving systemic regulators.

The most necessary point of the difference between structure and aggregates in the arguments of Piaget and Maschler (1971) is that structures are whole, and aggregates are composites formed of elements that are independent of the complexes into which they enter. He continues that insisting on this distinction does not, by any means, deny that structure is composed of elements that are subordinated to law, and it is in terms of these laws that the whole structural system is defined. Furthermore, the laws controlling the composition of a structure cannot be reduced to the simple, one-to-one, association of its elements, as they need on the whole an overall property that may differ from the properties of its elements.

The other study of the relationship between the concept of structuralism and social systems is Nabih (1998), who says that the structure of society depends on its elements and on three levels of interaction: the relationship between an element and itself; the relationship between an element and other elements; and finally the relationship between an element and nature. So, if any of the structural elements does not have any relationship with the other members, it would have no identity and would not contribute to the structure of the object.

The performance of any system depends on the relationship between it and its environment, as well as the other systems in that environment. Consequently, judging the performance of a system should be carried out as part of the larger system that contains it. The components of a system may be either subjective or objective, visible or invisible, and their relationships may be visible or invisible (Islami, 1998). A system also has two levels of meaning: the lateral or the direct interpretation, which in philosophy is known as the denotational meaning, and the hidden, symbolic and cultural meanings that goes beyond the direct meaning and is called the connotational meaning. For example, the denotational meaning of a pen is an object that produces writing. But how much writing has this pen produced? How many beautiful ideas has it produced that have had an impact on both the individual and the development of society? These are connotational attributes, the hidden meanings (Ujam, 2007)<sup>ii</sup>. Applying this to the muqarnas, the denotational meaning of the muqarnas is that it is a miniature niche structure. However, the muqarnas also has many connotations, semantics, memories, aesthetics, symbolic values and indirect meanings, which will be illustrated in this chapter.

For structuralists, structure is a system that is subject to a continuous programme of input, process and output, leading to its progressive replacement. Boundon (1971) believes that structure can be defined as a system of relationships. He states that these relationships are stable. He believes that the set of relationships characterises the structure. The system of relations is thus perceived as the basis of the structure, and structure is a formal system of relations of certain logical types, and the emphasis is on the relations rather than on the terms or entities that they relate. So,

how can it be used to address and understand the muqarnas? Structuralism is an epistemology<sup>iii</sup> that is applied as a tool for studying the muqarnas.

Boundon (1971) adds that a process can be called structurally stable, since the structural parameters are constant at all the times considered. The concept of structure can thus be extended to the analysis of process. He argues that structuralism may reveal the hidden aspect of things or even describe the deep meaning of things. Structural description always emphasises that the parts of an object are dependent upon the whole, which is the object. Hence, the concept of structure, basically, depends on this process of transformation and the transformation process itself is a key concept in understanding the whole and how it works. These notions and their relation to the muqarnas will be discussed throughout the chapter.

In relation to other disciplines, structuralism was initially based on the fields of mathematics, logic and language, before becoming more general (Hillier and Leaman, 1973). That is why structure is believed to be a set of logic–mathematical relationships that underlie the morphological variety and emergent properties of systemness (Islami, 1998). However, structuralism started as an attempt to discover the internal relationships responsible for giving language its form and function. Afterwards, anthropological studies were involved, especially the study of myths, which are of the nature of language, to the structures of the unconscious, as they are revealed in psychoanalytical discourse, and it was applied to the structures of literary language as well as of the plastic art with their language of forms, and eventually to the remaining sciences (Luchinger, 1981).



Hillier and Leaman (1973) argue that structuralism has a greater role than contributing to the emergent synthetic paradigm of science; it is a paradigm of creativity. However, structuralism is considered to be the science that forms scientific bonds between disciplines, such as theoretical biology and the analysis of myths, art and mathematics. Yet the dimension of time was interdicted to biological science through the theory of evolution. There are certain laws of composition that define the muqarnas as the mathematical rules for structuring muqarnas. Thus the computerised version of the muqarnas could be identified as the genotype, it has rules and laws. Rules and laws are part of the thinking of structuralism; basically any phenomenon is governed by the laws of composition. This will be explained further later throughout this chapter.

In general, structuralism was used in architecture as a tool to understand human behaviour, unlike the instrumental system, which was used in architecture as a decision-making tool. Structuralism is thought to be the most important modern movement in architecture and art design. It appeared in response to the movement of functionalism, which was well known in the early decades of the twentieth century (Heuvel, 1992).

In this regard, Newman (1961) claims that structuralism was first introduced into architecture at the CIAM 59 in Otterloo by the Dutch architect Aldo van Eyck, who was influenced by the anthropologist Levi Strauss, and was one of the pioneers in establishing the link between structuralism and architecture by studying the

relationship between social structure and the built environment. He suggested that the role of the architect is to understand social behaviour and the user's requirements, referring to the user, not to his own personal vision, then to accommodate this in the built form (Nabih, 1998).

Furthermore, the built environment could be considered as a system of transformation of physical and socio-cultural space which can be understood not only in the course of the three-dimensional buildings, but in a space-time process (Masaud, 1996). However, Aldo van Eyck believed that place and occasion mean more than space and time, because, in the image of man, space means place, and time is occasion (Hertzberger, 1991). In fact Aldo van Eyck sought a unity between building and people: a unity which should bring people to the city and to the community, to the place and to the space. This structuralist approach is the consistent nature of all his principles, of all togetherness. Hertzberger explains this saying that:

It would be something if everything we made encouraged people to become more closely acquainted with their surroundings, with each other and with themselves. This implies arranging differently, so that the world, in so far as it is amenable to our influence, becomes less alien, less hard and abstract, a warmer, friendlier, more welcoming and appropriate place; in short, a world that is relevant to its inhabitants. (Hertzberger, 1980, p.38).

Applying this approach to the muqarnas, the research postulates that the muqarnas is a system of transformation, because it has hidden rules that maintain its function and laws, adopted and accompanied by the social transformation of the Muslim community, which transforms the muqarnas by encoding geometrical and cultural meaning into hidden rules. Thus rules are responsible for producing and expressing the mathematical and geometrical meaning in the computerised version of the

muqarnas. Therefore, the mathematical and geometrical meaning will be used in this study, introducing change into the muqarnas phenomenon, and transforming it to suit modern demands and use. The development of the muqarnas, using spreadsheet software to read its transformation from the deep structure, will be discussed in chapter five of this thesis. However, the notion of structure incorporates a number of key ideas, discussed below.

### **4.3. Deep structure and surface structure**

A structure is considered as an abstract set of formal relations underlying the greater manifestation of observable forms (Hillier and Leaman, 1973). Chomsky distinguishes between a surface or perceptual structure and a deep or conceptual structure.

Deep structure is identified as an abstract underlying order of elements that makes possible the functioning of transformational rules. The rules map deep structures onto surface structures. It is then seen as a generative or transformational process, not only as a system of visual relationships. Deep structure, in his opinion, is partially defined by universal rules. (Patin, T. 1993, pp. 88-100).

By distinguishing between deep and surface structure, Chomsky allows for both description and formalisation. He sees only two alternatives, either an innate schema that governs with necessity, or acquisition from outside.

Hence, one cannot detect the identifying criteria and essential components in a straightforward way by just looking at the surface appearance of the physical objects instantiating them (Balzer and Moulines, 1996).

Structure, as a theory, illustrates the set of phenomena it underlies, by clarifying how they could be produced by applying the laws of transformation to an underlying structure. It is the deep structure and transformation laws that produce surface structure. A surface structure is thus the transformation of a deep structure. Deep structure is fully equivalent to the normal meaning of the term structure. A formal model for this general relationship is: structure  $\rightarrow$  transformation rule  $\rightarrow$  observable form. In Linguistics, deep structures represent the basic grammatical relations.

Structuralism suggests deep abstract formation as the basis of richness and variety and its application returned structure to the surface level (Hillier and Leaman, 1973). Assiter argues that structures are the real things that underlie appearances, and they are usually opaque to the eye. But Marx suggested that if there was no difference between the inner structures and the appearance of things, we would have no need of science (Assiter, 1984, pp. 1-2).

The search for deep structures results in an interest in the details of transformation laws. Applying this to social structure, Piaget refers to Durkheim's thoughts that behind concrete social relations there is always a conceptual structure, discoverable only by elaborating abstract structural models (Piaget and Maschler, 1971).

According to Eiseman, the surface level is about the sensible aspect of architecture and deep level is the syntactic aspect. He was interested in internal structure, that aspect of structure that goes beyond function to look for the innate structure or order of things. All this he constructed within a hierarchical order. For such structuralists,

the surface level corresponds to the physical aspect of architecture, and the deep level corresponds to the syntactic aspect. Deep structures concern implicit, underlying relations, an abstract order. Deep structures provide an abstract conceptual framework for the formal regularities (Eiseman, 1994). Eiseman refers to Chomsky's idea of deep structure as a model for describing the processes through which the physical aspect of architecture is derived or generated from a series of abstract formal regularities, another level at which formal relationships interact. He quotes Gandelsonas's claim that deep structure allows for an analysis of the interaction of the surface and deep structural levels (Eiseman, 1994).

For Boundon (1971) the concept of structure is very close to the concept of essence. What classic structuralism desires is just this essence, a pure form beneath the observable content, which produces an effect from the repetition of merely relational oppositions. He claims that deep structure and morphological surface change in time and space, with stability. Rossi (1982) believes that the morphological structure, which weaves the parts together, is abstract and material at the same time. Thus structure is a reality, which is immaterial but manifests itself materially (Mukarovsky, 1978).

Hillier and Hanson (1990) discuss some of the physical characteristics of structure. They mention the importance of physical aspects by saying that to believe with some that 'structuralism' may reveal the hidden aspect of things or even to wonder whether structures describe the essence or the deep meaning of things prevents one from understanding the concept of structure. According to Herbert and Thomas (1997),

structuralism is concerned with grasping the meaning of underlying structures. It is a holistic scheme that views patterns and processes as largely affected by structural imperatives.

Surface structure indicates the designing of the muqarnas itself, its ornamentation and decoration, its location and all the visible aspects. Deep structure is the meaning and the force responsible for producing designs and rules with such geometrical, mathematical and cultural meaning.

#### **4.3.1. Typology**

The term typology is derived from the two Greek words (typo) meaning “type” and (logos) meaning “word” (Comrie, 1989). Typology offers an explanation of how a building type develops and evolves over a period of time, becoming a recognisable element, which is strongly linked to the roots of the phenomenon of the muqarnas. It can be recognised as a branch of a muqarnas-specific architectural theory that greatly acknowledges the preceding examples of solutions to the ideal of decorative arrangement, mathematical–logical rules and the physical idea of a functional connection between many elements of buildings.

One of the first exponents of typology was the Quatremère de Quincy (1755–1849) who stated that "The word type presents less the image of a thing to copy or imitate completely, than the idea of an element which must itself serve as a rule for the model" (Hill, and Evans, 1972, pp.231-274)

This concept suggested a methodology of formalising, promoting and replicating archetypes but instead wanted an acceptance that when depicted in their unembellished construct there is a formal and functional connection between many elements of buildings. It is an abstract definition that, through the reduction of a building's elements, allows the neutralisation and recognition of the basic principles that dictated its form and its evolution over a period of time.

According to Hill, and Evans, "typology is the systematic classification of the types of something according to their common characteristics".(Hill, and Evans, 1972, pp.231-274). Types are a product of the evolutionary process that is responsible for the construction of cultures and identity, that in turn give man the ability to orientate himself. In linguistic terms, each place has its own intelligible dialect which enhances the uniqueness of the *Genus Loci*, but there are also shared characteristics that are common across a range of diverse cultures resulting in slight variations on one typology. Type can be said to continue to evolve until it reaches its rational, coherent and purest form, whilst revealing its past and present through a type-form that resides in its physical composition.

The birth of a type involves there being a series of buildings that have between them an obvious formal and functional correlation. In order to determine type, a series of buildings are exposed through the elimination of individual elements until the remaining form is that which is common throughout the series. For example, various forms of accommodation that serve as homes all have the same basic function. The act of identification of a particular element is an essential process in the

representational and description of a particular artefact. The process of recognition itself implies a deification, the establishment and relation of common characteristics within a similar class of things.

Typology is more significant than merely vernacular architecture, it appreciates the need for building types to respond to change and adapt with the transformation and advances in technology and cultures around them. This results in a constant fluctuation and modification of buildings with additions and reductions being absorbed into the lineage of the building type. An example of this can be found in the many new building types that emerged during the Victorian era, when new knowledge and materials, combined with demand created by new methodologies and advances, resulted in the creation of a set of building types based on their physical functions, e.g. hospitals, schools and train stations. We are possibly at the edge of the next generation of technological progression and need to consider the ramifications and requirements of life and work in the twenty-first century.

Type is very historically derivative, in a non-imitative manner, but many recent artistic movements have attempted to disregard past examples of work as a means to progress unaffected by their influence. The rejection of type and its advancement of intuition is a key factor in the Modern Movement's rejection of historic forms. However, even a departure from type in the form of a countertype is an acknowledgement of its existence, thus maintaining its influence despite being disregarded. That is an example of artistic invention against historic experience, for education is an inherent constituent of experience.



Leon Krier claims that "A type is an artefact intended for a specific use, having become a carrier of meaning through familiarity" (Krier, 1984, p. 70), giving a muqarnas the required identity that enables us to orientate ourselves within it. Through this familiarity we are able to appreciate the significance of surrounding phenomena, our memory being typologically prefigured to enable us to make sense of environment.

The typology of a certain locality is one that has been constructed over a great period of time, absorbing the history and relevant issues to form a muqarnas rich with meaning. The imposition of an object that has little in common with its surroundings and disregards the development of the muqarnas through time results in a building uninformed by the history and deep meaning entrenched in both the building type and the muqarnas.

The characteristic of our age is rapid changeability, but there is not a fixed and immutable link between form and meaning. The theory of typology is open to new adaptations and variations of types but rejects the increasing importance of style over substance and the pre-eminence of technology and objectivity apparent in architecture today.

[T]he worst enemy of modern architecture is the idea of space considered solely in terms of its economic and technical exigencies indifferent to the idea of site (Frampton, 1992, p.524).

In an attempt to create a new vision, the present research suggests that understanding the phenomenon of the muqarnas should be extended to a more semantic basis. In

other words, the study claims that the muqarnas is a structure that can be examined in terms of its continual flow through time.

The universal of place is action of style which is contradictive of a place making process position. The increasing commoditisation of the built environment reduces the ability of meaning to be developed and encapsulated through the continuation of an indigenous building type, thus causing a situation where developments frequently have little relationship with their context. The meaning of the place becomes weakened through the proliferation of irrelevant external influences.

When we find ourselves in a situation devoid of any significant meaning or suffering from a contrived sense of place we struggle to gain an important attachment to our context. The concept of belonging to a place is one that cannot be overestimated, as it is a profound ingredient of human existence; when a meaningful connection cannot be achieved then there cannot be a complete experience of place in its totality. It is equally important that we appreciate the methodology by which we understand and are able to 'read' our environment; that which enables us to derive meaning from individual elements and the complex network of relationships that exist between them.

#### **4.3.2. Form**

In art and design, "the term is often used to denote the formal structure of a work, the manner of arranging and coordinating the elements and parts of a composition so as to produce a coherent image" (Ching, 1996, p.34). In architecture, form is the point

of contact between mass and space (Bacon, 1974, p. 45), emphasising two phenomena that are related to each other.

Structure consists of elements that are connected by relations. These elements might form substructures within the main structure. This structure, or the elements and other substructures, is considered as content to another structure at a higher level. At the same time, this structure will stand alone or with other structures as a content of a structure of a higher degree through an order of hierarchy. This hierarchy will emerge through continuous change under the effect of dynamism. In structuralist discussions like de Saussure's structural anthropology, dynamism focuses on the way elements of a system combine together, rather than on their intrinsic value (de Saussure, 1966). As a result, structure is form is the principle that gives unity to the whole.

While form includes a sense of three-dimensional mass or volume, shape refers specifically to the essential aspect of form that governs its appearance – the configuration or relative disposition of the lines or contours that delimit a figure or form (Ching, 1996, p.34).

This type of understanding enables researchers in structuralism to concentrate on the coherence and completion of an indivisible entity.

In architectonic terms the forms of the muqarnas that are the result of the interrelationships between geometric design and numerical system involve the measuring and dividing of available dimensions for the purpose of laying decorative muqarnas through the use of lines, circles, triangles, squares, rectangles, pentagons, hexagons, and polygon forms without the use of science or numbers. The circle,

which is a symbol of perfection in plane geometry, is the starting point for planning architectonic form in Islamic architecture (see Fig. 4.1).

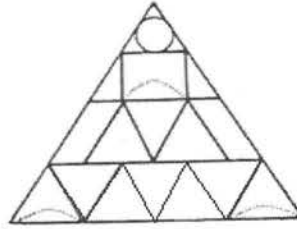


Fig. 4.1. Triangle with some repeat geometric designs

The circle has laid down the concentric plan in Islamic art in the sense that Muslims in general are drawn to the centre of all existence that is the creator. In the context of this study, the muqarnas make the perfect circle, square and triangle a visible space that can be divided into equal unit parts to create architectonic forms.

The artist can divide a given surface into two or more equal parts, simply by converting the given area into 2, 3, 5, 10, 20 or other equal folds in order to obtain the number of unit parts needed for expressing geometric patterns (El-Said, 1976, pp.2–3).

In this respect, the use of numbers to plan geometric or available space is vital for the repeat muqarnas designs and the use of colours, texture, position, orientation and visual inertia, so as to produce a coherent effect in the science of architectonic forms and to create the magnificence of the everlasting beauty of the muqarnas.

#### 4.3.3. Space

The concept of space has more than one meaning depending on the theme used and on our perception of the spatial boundaries defined by elements of form. "A space is a three-dimensional volume that can be empty or filled with objects, it has width,

height and depth" (Emmerling, & others, 2003, p.534). Space constantly encompasses our being. "As space begins to be captured, enclosed, moulded, and organised by the elements of mass, architecture comes into being" (Ching, 1996, p.92), and also, "It is set apart in a given instance or for a particular purpose, in which objects exist and events occur, and it has relative position and direction" (Ching, 1996, p.382).

Ardalan and Bakhtiar stated that in structure space is the most direct symbol of being, and in the cosmology of Islam,

it is the 'locus' of the Universal Soul, "in which the universe is composed of a macrocosm and microcosm, each containing three great divisions; the body (*jism*), the soul (*nafs*), and the spirit (*rūh*)". This conception has raised two interpretations: the Manifest and the Hidden, which considers God as Manifest (*Zāhir*)<sup>iv</sup>, and God as Hidden (*Bātin*)<sup>v</sup> (Fig. 4.2), pertaining to "qualified" and "sacred" space. God becomes the reality that en-globes all, that "covers" and "encompasses" the cosmos. (Ardalan and Bakhtiar, 1973, pp.12, 13).

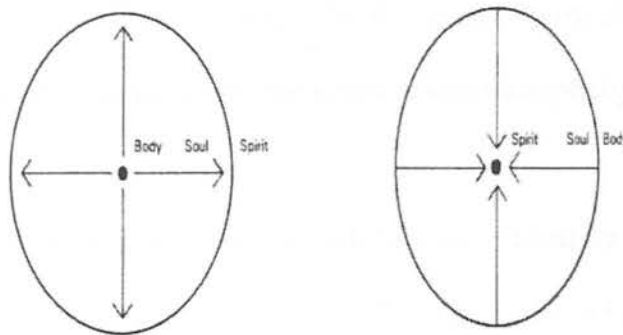


Fig. 4.2. Manifest and Hidden

The relationship of space to shape is perceived in distinct levels of interaction. The muqarnas is viewed as an active shape bounded by a positive space. Moving within the three-dimensional mass of positive spaces creates interactions with negative, passive shapes. Through the use of geometry and mathematics, a vital positive space

carves a hierarchy of negatives. The muqarnas is viewed as an active quality of positive space carving the spatial connection that flows rapidly through the transition,

like air moving through a Venturi tube, and expands into the culminating space, pushing the membrane of the dome outward and making it taut; transforming the walls of the room into transcendent niched volumes; and turning the ornament of surfaces into poetic testaments of the will of the soul to return from whence it has come. (Ardalan and Bakhtiar, 1973, p.17).

Art and architecture are therefore united in transcending the boundaries of a given physical space by spiritual means, making material structures transparent for the manifestation of eternal truth. The most striking architecture and decoration, however, is to be found in the muqarnas (miniature) niche structure; they are a perfect realisation of the principle of subdivision and integration and seem to have sprung from the passion of artists and architects for expressing the interrelation of these principles, by either differentiating an elementary spatial unit – the niche – into a multiplicity of related smaller forms, or by bridging step by step the subdivisions between individual smaller units and thus reconvertng multiplicity into unity.

Space is defined by surfaces and, since a surface is articulated by decoration, there is an intimate connection in Islamic architecture between space and decoration. It is the variety and richness of the decoration, with its endless permutations, that characterises buildings rather than their structural elements, which are often disguised. The muqarnas are explained by a desire to dissolve the barriers between those elements of the buildings that are structural (load-bearing) and those that are ornamental (non-load-bearing).

The tendency is for surfaces to be fluid: decoration helps to make the transition from one plane to another imperceptible. No sharp divisions are allowed. Light is filtered; water reflects, unifies and cools. (Jones, 1991, p.162).

Decoration in Islamic architecture serves several functions and includes techniques to organise space to emphasise the structure, the balance and counter-balance of loads and stress in the mechanics of a building. Islamic architecture aims at a visual negation of the reality of weight and the necessity for support. The various means by which the effect of weightlessness and unlimited space, of insubstantiality of wall, pillars and vaults is created range from moulded and deeply cut stone or plaster to actual openwork and pierced walls, vaults and even supporting pillars. The multitude of decorative treatments of surfaces in Islamic architecture, the use of almost every conceivable technique and the development of a rich repertoire of designs – from geometric abstract shapes to full-scale floral patterns, from minutely executed inscriptions in a full variety of calligraphic styles to the monumental single words that serve as both religious images and decoration – is without parallel in the architecture of the non-Muslim world.

Its effect is extraordinary and its function quite unmistakable. It combines an infinite completeness of individual units (bays, arch, columns, passages, courtyards, doorways, cupolas) and continuous merging of spaces without any specific direction or any specific centre or focus (Grube, 1991, p.11).

The harmony and the sense of unity of a building can be enhanced by relating all the different parts to the same “generative unit” by means of a limited number of geometrically determined proportions" (Wilbrun. 1955, p. 140). Proportion is to space what rhythm is to time and harmony to sound. The idea behind the use of proportions in Islamic art and architecture is that the ideal system of beauty which

permeates nature can be expressed by allocating space in conformity with predetermined proportions.

#### **4.3.4. Ornament**

One of the most remarkable features of the Islamic tradition is the predomination of ornament. Ornamentation has played a major role in interior and exterior decoration in Islamic architecture, whether it is religious or civic. The most common among these are interlacing floral patterns, geometric patterns and calligraphic inscriptions. The patterns are used to decorate minarets, minaret balconies, parapets, domes, arches, arcades, windows, screens, door/window lintels, glass windows, lamps, mihrabs, minbars, chairs, etc.

The Islamic conception of an omnipotent, omnipresent and omniscient 'Allah' God determines artists' attitudes. Since the basic characteristics of all objects are apparitions of the divine will, art gains a religious character and man-made products become sacred. As a result, the productions of men and natural objects preserve their intrinsic structure and characteristics in Islamic art. With this joyful quality, Islamic ornament produced on a plane aims to exist on that particular plane and not extend beyond it. Throughout the Islamic ages this has produced a unique sense of divine beauty and tranquillity which has no other example in human history.<sup>vi</sup>

With regard to decorating with statues, Islam forbids their use because Islam came to the Arab peninsula at a time when the majority of the population were idol worshippers. Under the new religion the worshipping of idols and use of statues was



strictly forbidden under any circumstance. Similarly, it disapproved of paintings, especially human and animal paintings, to prevent any return to the worshipping of idols. Thus, with the total absence of figural decorations in mosques or religious architecture or in its civic architecture, other permissible ornamentation substitutes were found. This may have contributed to the flourishing of floral and geometric patterns as muqarnas and calligraphic decorations.

Floral ornamentation<sup>vii</sup> achieves a contrast between repetitive alternation of light and shade effects, and differences in the intensity of pattering. The main vocabulary is grape and palm leaves and stems. Plant symbolise life, implying that the place is a place for life, including all activities indicating life, and offering multiple activities and functions for society. Furthermore, the growth of plants is a dynamic process, which complies with the nature of Muslim society being in a continual state of dynamic development (Awad, 2000).

Geometric ornamentations were established upon the repetition of certain geometric units. This started as a simple composition of lines forming interlacing spaces, and then become more complicated, creating endless compositions through the combination of geometrical shapes with different proportions. These compositions developed professional, technical and creative capabilities. These ornamentations demonstrate the genuine artistic background, the deep knowledge and skill of the Muslim artist.

Ornamentation methods have been interchangeable, used in gorgeous variable combinations, either side by side in the same element, or even sometimes in more complex and interlacing forms in a single piece of work. Such complex combinations might be between geometric and floral ornamentation, or with two styles simultaneously, or between two different calligraphic styles, or even with three styles simultaneously. In many regional styles of Islamic architecture, this effect is further reinforced by the character of the ornament used for walls, floor and ceiling, which are sometimes converted into architectural forms. Through its renunciation of naturalistic representation, Islamic art has gained a special aptitude for dealing with large surfaces. By concentrating on calligraphy, floral arabesques and abstract geometric patterns, it has been allowed to convey a timeless message, related to the word of God, to the eternal patterns of creation and the rhythmical processes of growth and decline of the transient world. Through ornamented wall surfaces, these messages are imprinted on the enveloped space, which thus acquires a timeless dimension, reminding man of the divine origins of creation.

#### **4.3.5. Laws of composition**

Laws of composition are responsible for the organisation of the elements and relationships inside the structure. In other words, they form the order of the structure. This order will confine the system that constructs the structure in a hierarchical manner by which the structure reforms its substructures and relations within a systematic order.

A structure is a system of transformation. It is a system, which means it is only a collection of elements and their proper ties, but there are laws which govern and control the system and its components or elements. Transformation can not happen or occur without these laws, which in reality, are part of the process that keep and maintain the interaction between the elements.

The deep structure and the surface structure, and how deep structure is transformed into surface structure will help us to understand the muqarnas from this point of view, in which the muqarnas embodies the mathematics involved in structuring geometry. Thus rules identify how the physical elements and mathematics are related in harmony. Rules and laws are part of the thinking of structuralism, which holds that basically any phenomenon is governed by the laws of composition.

The relationships between the elements of a structured whole or a system need to follow specific laws and certain rules. Laws of composition represent the character of structured wholes, and these laws also govern the transformations of the systems which they structure and through which they are defined implicitly. The structural elements are co-ordinated to the rules and cannot exist independently, and distinguish the whole from an aggregation (Piaget and Maschler, 1971).

The idea of a rule is fundamental in a structure. It is the base upon which the concept of structure is built. A structure is a co-ordination of a set of rules. Structure implies a unified set of laws having their own internal logic (Hillier and Hanson, 1984).

Not only does the presence and the function of a structure depend on the rules but also the regular changes and transformations are made by following consistently applied underlying laws (Giddens, 1984).

Laws of composition determine the performance of the whole system. Laws of composition regulate the flow of power within the whole system structure. From the physical or the surface structural point of view, they determine how the muqarnas fit or belong to the building, and how structural axes and movement systems are related to each other functionally or physically.

Throughout the above analysis, it appears that there are principles and rules that govern the substance of the muqarnas and define its role, and which embody the mathematical principles involved in structuring it. It is important to touch on this point to set the basis for any study addressing the muqarnas, because the initial distortion of the meaning of the muqarnas appears to have come from ignoring these laws. This issue was raised by Ujam interview (2007).

The best way to transfer the ideas of structuralism from the domain of philosophy into the domain of architecture is by physical and mathematical harmony. The classical stage of physics is to preserve the fundamental conservation principles that give coherence to the theory. Applied to the deep structure of the muqarnas, this refers to the interaction between people, who transform the notion, turning the geometrical and cultural meaning into rules. These mathematical and geometric rules are responsible for identifying the position of any component within the system, so

the laws of composition bind them together. Hence, it could be concluded that the muqarnas is a multifunctional part of a structural arrangement that constitutes the whole system that has maintained its rules throughout its transformation.

#### **4.3.6. Hierarchy**

According to Ching, hierarchy is "a system of elements ranked, classified and organised one above another, according to importance or significance" (Ching, 1996, p. 381). The Oxford English Dictionary defines hierarchy as a body of things ranked in grade order, or classes, one above another. The structure is influenced by the ordered relation of parts to a whole, being arranged in a manner in which the components are connected together. According to this order, a component of a structure can be understood by integrating it into the higher-order structure. Structuralists always see hierarchy as the mutual subordination and super ordination of components in a state of constant regrouping.

Hierarchy is considered a type of patterning signifying interaction between elements expressed in reproduction or continuity of interaction in time. It is the organised complexity of a structure, where each level is more complex than the one below. A higher level is characterised by emergent properties that do not exist in the lower levels. Hence, it is not an aggregation of elements, but an expression outlining a set of relations between things controlled by some major formative laws (Open System Group, 1981).

Piaget and Mascher (1971) explain that the ordered relations of the structural elements give rise to a specific ranking and lead to a distinct classification activity, so the setting up of correspondences becomes quite systematic. Levi-Strauss refers to hierarchy, saying that every form is content for higher forms and every content defines the form of what it contains.

Structuralists always see hierarchy as the mutual subordination and super ordination of components in a state of constant regrouping. In such a process components are significant for the whole meaning of the structure, which constantly changes in response to their regrouping. For them hierarchy could be assumed to be a kind of patterning, implying interaction between elements in which relations express themselves in reproduction or the continuity of interaction in time.

In biology, there is a hierarchy of structure realised in a living organism: molecules, organelles (entities responsible for the organisation of the cell), cells, organs and the organism. The features of each level are different from the level above and complexity increases, until it reaches the ultimate object, the organism, which has an identity as a whole. This identity is formed from such a hierarchy, where each level is more complex than the one below it.

The principle of hierarchy that applies in the ornamental patterns of Islamic art, its principles of subdivision and integration, are interdependent aspects of a total architectural composition, which emphasises both autonomy of single elements and the inclusion of individual units in larger ones. The result is a perfect balance

between the “part” and the “whole”. The concept of hierarchy in the muqarnas can be related to the different rules in architecture and decoration; Symbolically speaking, this geometrical process of differentiation and integration may be seen as an image of the unfolding and retraction of the created world, as often evoked by the *ayats* (verses) of the Qur'an, and are representative of the Islamic principle of unity (*tewhid*) oneness.

#### 4.3.7. Order

According to Ching, order is a condition of logical harmonious or comprehensible arrangements in which each of a group is properly disposed with reference to other elements and to its purpose (Ching (1996, p. 381). A structure focuses on

The ordered relations of parts to a whole, with the arrangement in which the elements are linked together. Based on this order, elements of a structure could be perceived by combining into structures of a higher order. The ordering process allows the maintenance of the system. (Hamidi, 2003, p.26).

Levi-Strauss pointed out that structuralists' attempts to discover the order behind various phenomena do not seek to equate phenomena with an order constructed in advance, but rather that reproduction, reconstruction and reorganisation were necessary in relation to reality (Luchinger, 1981). But Piaget refers to the order and hierarchy of the structure itself on the one hand, and structure and substructures on the other. There is no hierarchy without an order. Every structure is form and content at the same time. By this concept, there is order and hierarchy in the structure that is made from lower-level content, and at the same time, it is content for a higher form. So there is an order for this hierarchy, with the same criteria, structure and substructures all connected (Piaget and Maschler, 1968).

For an organism's wholeness, the importance of biological organisation is the mutually constituted interrelation of the organic components. The organism's order refers to both the spatial and temporal configuration and sequence of events. Spatial order is the morphology or structure of the organism, while temporal order is its function or physiology. For the organism, there is an everlasting orderly process, which is sustained by underlying structures and organised form. Organic forms or structure in morphological description are, in reality, a momentary cross-section through a spatiotemporal pattern (Bertalanffy, 1952).

Structural order leads the process in such way that a certain result is achieved. There are affinities between these organic rules of architectural aggregation and the more formal principles of artistic composition applied in the ornamental patterns of Islamic art. The geometrical patterns show a most conscious abstract composition. However, they are equally building up on interlacing and superposed basic figures which together form an intricate fabric, the unity of which can be distinguished at various levels of the total composition. The consistent use of repeated and variegated geometrical archetypes produces the impression of both complexity and unity through a continuously flowing pattern, held together by a carefully traced frame which defines the field of action.

#### **4.3.8. Wholeness**

Wholeness is one of the most significant characteristics of the structure. All structuralists, mathematicians, linguists, psychologists recognise as fundamental the



difference between structure and aggregate or collection. The former acts as a “whole” while the latter is a combination formed from elements.

The composition of wholeness is of a totally different order than the aggregation of parts. In aggregation it is important to add the parts together; in a system it is important to arrange the parts together (Mathews, 1994).

Structuralism attempts to grasp reality as a whole, in which part and whole are seen simultaneously. It is the whole that gives the part its defining characteristics in that physical situation. Piaget (1971) states that a structure (in the most general sense) exists when elements are united in a whole which presents certain properties as a whole and the properties of the elements are wholly or partially dependent on those of the whole.

The sum of the criteria applied to the performance of a part of a system is hardly equal to the criteria applied to that of the whole. Such a mass-collectivity of the unity of man-made products in Islamic art, a group of individualised tectonics with equal importance in relation to infinite space obviously creates an additive, cumulative, mass-collectivity. The characteristic of the Islamic concept of unity is “ornamentalism” reached through the application of a transcendental approach to the objective plane. In these terms, ornament is the shaped linear decorations of a surface, with ornamentation being a system of such elements, whereas ornamentalism comprises the reaction of the form of the ornament to the surface on which it appears or it is a specific organisation of tectonics in space.

The objects of Islamic art are a comprehensive and meaningful human environment, leading to sense of responsibility in human development, by combining architecture, interior decoration, furniture, books and many objects of daily use. To suppose that everything in the universe has a sole creator is the main foundation for perceiving it as a whole unity. It is argued that existence has always been considered as a unified whole, namely *wahdat el-Wujood*, which means 'the unity of existence'. Existence is a manifestation of an omnipotent, omnipresent God, one and only one, who is the creator of everything and nothing can exist or happen beyond His will and power. In other words, there is no such division between people and the universe, where people themselves, as part of the universe, reflect the divine. Therefore, the universe and its container, being associated with God, are a unique, sacred, united whole. Ornaments and calligraphy that are produced on a plane, aim to exist on that particular plane and do not go further in or out. Through this, Islamic art emphasises the notion of unity in that all the elements together create an architectural form, including space, shape, light, colour, and matter, rejecting sharp distinction between secular and sacred architecture (Nasr, 1971).

As discussed earlier in this chapter, the notion of structuralism is necessary for the understanding of the idea and meaning of the artefact of Islamic decoration. It is recognised in the parts of the system, as it is acknowledged in the cultural norms, laws, and practices that govern the individual elements of the ornamental, which have deep roots in all aspects of Muslim society. Consequently, in the built environment, and the muqarnas in particular, it is necessary to study the history of

features and elements, how they evolved and how they have become organised into an overall structure.

#### **4.3.9. Transformation**

The research sheds light on the transformation of the muqarnas to suit modern use without losing its meaning. In the introduction of a new version of the classical muqarnas the author is transforming the hidden rules maintaining the functioning and laws of composition of the muqarnas. Hence transformation is an ongoing process of change in the designs of a muqarnas, the author is inviting the architect and the artist to go beyond simply repeating or copying the surface structure to look to the deep structure, from which comes the different forms and shapes following the cultural expression. Culture is not static but in a state of evolution that might present relativities in the development of its knowledge. Jon Lang discusses how cultures are unique, mainly because each culture has its own historical background. A culture is the product of long-term interaction between people in both their physical and social environments. Therefore, it is impossible to find two societies sharing the same situation in the historical perspective (Lang, 1988).

According to Ching, "transformation is the process of changing in form or structure through a series of discrete permutations and manipulations in response to a specific context or set of conditions without a loss of identity or concept" (Ching, 1996, p.382). Time and change are very important dimensions in studying the transformation of any system. According to Webster's International Dictionary change is to make over a radically different form, composition, state or disposition.

Evolution is the progressive development of civilisation and social institution in a fixed sequence of stages. Transformation is the changing of an expression, formula or statement in logic into a different form without altering its substance or intent. All in all, transformation is an increase in the complexity of the content.

According to Piaget, transformation is 'the constant duality, or bipolarity, of always being simultaneously structuring and structural' (Piaget, 1972, p.10). It is an ongoing process of change in form that could be applied to nearly all phenomena, for example, muqarnas ornamentals are systems of transformation of its physical elements and designer-cultural aspects, in which particular forms in nature have been transformed over time into mental structures which resemble the original forms of nature for previous contents and content. The author will introduce a modern version based on the idea of transformation, which by maintaining the elements and functions, transforms the hidden rules defining the functioning and laws of composition of the muqarnas.

Piaget claims that transformation is always passing from a simpler to a more complex structure. Structure is a system of transformations that involve laws. Structure is preserved or enriched by the interplay of its laws of transformation, which never yield results external to the system nor employ elements that are external to it (Piaget and Maschler, 1968).

The line of transformation as belonging to structuralism can be traced to the theory of evolution that opened up the dimension of time in the biological sciences.

Moreover, the concept of evolution is correlated to the transformation of the forms and contents which comprise structures (Piaget, 1971). In architecture different components acquire their contents by shaping part of a structure that comprises symbolic values and people's perceptions. Changes in designs of a building will only be understood from within a culture since they are the result of social transformation (Masaud, 1996). It follows that in architecture the various components acquire their contents from their structure, which includes people and symbolic values. This is possible because, according to structuralism, the symbolic meaning and subjective values which emerge from the transformation processes become part of that structure.

However, continuity and transformation of the whole through time and over generations gives rise to the sustainability of the systematic interaction between people and their environment. This interaction develops in addition to the time concepts and is reflected in people's ability to construe certain events in the culture, and their knowledge of this transformation (Barati, 1997).

The influence of transformation on the muqarnas can not only be seen in the evolution of built ornamental techniques and methods over time, but also can be understood from the way its perceptual meaning changes over time. The arch and the vault are examples of transformation and evolution of an architectural element through time. However, they have also been influenced by changes in the design of the buildings they emerged from. How the muqarnas has adapted to its context, as one sees in the material used, can only be understood from within the culture, since

the changes are important markers of the transformation of pre-historic cultures into the first great civilisations.

#### 4.4. Identity

The identity of the structure of the muqarnas is very important in the context of Islamic art, because it has a cultural, consistent, meaningful and symbolic role. This refers to a persistent religious message that the Islamic work of art, regardless of medium, attempts to express in aesthetic terms. The core of that message is consistency and to have a charm in the elaborate epigraphic carvings in Islamic architecture. This allows muqarnas to be differentiated from one another. In other respects, considering their structural composition, the muqarnas presents an elaborate morphology drawn by the mathematical diffraction of prismatic overlapped volumes which constitute the technical principle of muqarnas decoration in general.

This metaphorical identity of the muqarnas lies in their specific visual configuration, built on an intricate three-dimensional geometrical composition that displays to the sight an astonishing rotating body, tending to grow like an organic being, penetrated by plays of light and darkness, and animated by strong optical effects of undulating motion. They offer marvellous visual spectacles,

like the atoms of a universe in formation, evoking the physical laws of cosmic bodies, whether real or imagined: up and down movement, concentric attraction or opposite repulsion, fragmentation, diffraction, aggregation, play of light, and so on (Gonzalez, 2001, p.82).

The term 'conceptual' does not mean the main principle that determines the geometrical system of the muqarnas, which is clearly not movement, pure formalism,

or metaphor, but the aesthetic expression of the concept of geometry as an ideal object. According to David Hume, an eighteenth-century philosopher, identity is the most universal relation which is discovered by perception rather than by reason. He proposed that mankind is nothing but a bundle or collection of different perceptions (Hume, 1967).

Amos Rapoport, wrote very extensively about the human aspect in design, wrote that:

Identity is a difficult concept to define. Dictionaries give multiple meaning, the two most relevant referring to the unchanging nature of something under varying aspects or condition; and condition of being one thing and not another. Both in fact seem relevant, but the latter notion seems to be at the heart of the concept as it applies to the question being considered. In some way and somehow, the unity in question sees itself, and is seen by others, as being different to other units. This would seem to involve both an inside or contents and boundary to the outside (Rapoport, 1981, p.10).

According to the Oxford Concise Dictionary, structure is the "manner in which a building organism or other complete whole is constructed".

A building is neither matter itself nor its materials, but the way in which these materials (by their physical properties) are assembled and combined to produce an object created for specific purposes and which has the capability to undertake well-defined functions (Ehrmann, 1970, p.2).

In other words, structure, can be identified by what we may call 'the relevant features of the object'. A structure will necessarily be an "abstraction" if it cannot be directly perceived by the senses as can the building itself.

The "abstraction" can be interpreted as a construct of the mind, which retains only certain features of the physical reality considered. So it is a pure and simple creation

of the mind in order to understand the object (Ehrmann, 1970 p.4). Thus one can see the idea of structure not as a characteristic of the object but as a model set up by the scholar in order to gain a better understanding of the object (Ehrmann, 1970, p.3).

#### **4.5. The meaning of the muqarnas**

The meaning of the muqarnas in Islamic art is a combination of craftsmanship and the physical expression of a particular spiritual vision, used as both a decorative and a structural element. As a sacred art, this creation is founded on a number of principles to produce the symbolism inherent in the elevations of the architectural and artistic design. The combination of the muqarnas' forms is much like a natural environment; a series of niches embedded within an architectural frame with exterior and interior decoration, including richly sculpted and textured visual objects that are geometrically connected and form a three-dimensional composition around a few basic axes of symmetry.

The construction has reason alone but architecture has meaning. Generally, science studies an existing thing and art seeks to create a new thing. Therefore, the great architect needs to find a basic harmony between the rational sense and inspiration. It would be regrettable if he or she reduced design to the application of laws that apply models of the muqarnas in use, and compared the outputs with the model (computer blocks). Art has not only an aesthetic value, but it is also a means of education, building character, and preserving and ensuring continuity of a people's historical identity and civilisation. It is our duty to absorb its concepts into our educational programmes and means of mass communication.



Najati (1980) argues that when people think or talk about their surroundings they do not carry the physical elements in their mind but are carrying only the symbolic meaning of those elements. Symbols are products of the imagination of mankind and enable people to make abstract ideas, original patterns and to manipulate vital information about various phenomena in the environment. For example, instead of thinking about the meaning and significance of muqarnas, it is more powerful and effective to consider muqarnas as the strongest force of expression of Muslim unification, *al-Tawhid* (oneness).

The muqarnas can be related to different roles in architecture and decoration. It can take the same role as Islamic decoration, which is often to evoke the Word of God made visible, so as to underline the signs (*ayah*) of the Creator in every conceivable form of monumental beauty. This means beauty reflected in both the inside and outside of Islamic architecture in two different forms: beauty in the calligraphic expression of the Word of God and beauty in the elegance of the spiritual thoughts of men in complete harmony with their surroundings. The adoption and application of a unique feature of Islamic architecture, the 'muqarnas', which combines the Word of God, geometries, expressions and repeat decorative verses has not only created a set of changeless artistic principles, but also, a system of architectonic forms. Therefore, in the following chapter the study will shed light on this movement in a computer, testing its applicability to the muqarnas as a programme that reflects many factors identified by the religious, social, cultural, and economic aspects and their interrelationships.

Muqarnas are considered to be an extension of geometric formations in space which assist in the transition between the square, circle and octagon. They consist of beautiful artistic components of diagonal lines for the curvatures, refractions, intersections and overlapping formations. Thus, formations of the muqarnas originated in a number of Middle East countries, such as Iran, Iraq, Syria and Egypt, then spread to other countries, such as North Africa and central Asia. The use of muqarnas culminated in Spanish Islamic 'Andalusia', and Turkey during the Ottoman Empire.

Therefore, the designs of the muqarnas vary according to their use. The design in the cornerstone angle differs from that of the walls, from that of the shaft of a dome, the dome itself, the capitals of the columns, the entrances, the recess covered by a hemispherical vault, the arches, the intrados arch, the mihrab, and the minaret. The muqarnas is three dimensional in shape and arises from arches of different geometric forms and sizes that are divergent in angle from each other to give aesthetic forms like beehives, which can be seen as a cascade of stalactites in the corridors, domes and portals of buildings. Thus, the impression can be conveyed by those interior solid formations in domes – of the Chamber of the Lions and the hall of two-sisters in the palace of the Alhambra, and in the tomb of Sultan Hassan, in Egypt, for example – that they are three-dimensional upturned elements cascading or hanging vertically downwards, defying gravity and defying visibility of the ray of ray system, as if the architect had left cascades of stalactites flying in the sky, or like icicles hanging from the ceiling of a natural cave. Accordingly, each of the carvings, whether protruding,

bulging-out, flat, cascading, concave or convex, and the surrounding lines and masses exhibit light and shadow such that a magnificent elegance and a sense of beauty prevail.

The harmony of the arrangement of lines and arches in the formation of the muqarnas attracts us with its immediate beauty that we can feel, think and be aware of through the shaping and creativity in the diversity of forms, including the sphere angle corner (concave composite muqarnas (*Shami*)), or spherical triangle (prismatic composite muqarnas (*Baladi*)) or stalactite muqarnas.

There are different muqarnas designs, depending on their uses and the relationships between them. Thus, there is what is achieved by the aesthetic system in the external and internal vision of the entire building and what is achieved by other, different parts of muqarnas arranged in an agreeable consistency, including the division and conformity of muqarnas as a unity. It is generally found under a cornice and above the bed-mould of Corinthian entablature, and at the same time, it hides the transitional zones between various surfaces (e.g. arches, domes, capitals, windows, ceilings, minarets, mihrab, minbar, façade and a variety of furniture) and consists of a number of shapes, in some circumstances resembling stalactites, which comprise consecutive cells of muqarnas arranged in harmony, either concave or convex; deeply set or protruding; and showing light and shade.

#### 4.6. Aesthetics and symbolism of the muqarnas

Aesthetics aim is always to create artefacts that can be admired even if they have other meaning or benefit. The easiest way to give a reason for liking or disliking any particular element is to give an aesthetic appraisal. Aesthetics always been an important subject in the arts and is a spiritual value or ideal, which has no accurate specification or definition; mankind has a wish to serve aesthetic ends. Whether mankind reaches or fails to reach his goal, the intention is there. The aim is. Aesthetic experiences are expressions of objects and emotion. To understand the nature of the aesthetic experience, Santayana found it useful to distinguish between the sensory, formal, and symbolic interaction between people and their built environment. Sensory aesthetic is concerned with the happiness of the sensation received from the environment. It involves the arousal of one's perceptual system, is multidimensional, and results from the colours, odours, sounds, and textures of the environment. Formal aesthetic in architecture is concerned primarily with the appreciation of the shapes, rhythms, complexities and sequences of the visual world, although the concepts can be extended to the sonic, olfactory and optic world. The appreciation of the associational meaning of the environment that gives people pleasure is the subject matter of symbolic aesthetic (Santayana, 1986).

Aesthetics has no absolute standards, but has been categorised as related to various viewpoints that are influenced by the surrounding factors. Thus, while consensus may exist that an object is aesthetically pleasing; individuals may disagree about the degree of this aesthetic by using terms like beautiful, nice, good and simple to indicate their satisfaction or preference. However, the old design of muqarnas as a

decorative finishing strip or corbel used in Islamic architecture has important aesthetic characteristics. Its variety of features serves to remind people about the past, providing insights into the cultural history of previous generations. Therefore, symbolic of muqarnas is a combination of symbols and principles of Muslim art and architecture, related to the history and traditions of Islam. The basis of Islamic art lies in the twin doctrines of faith and beauty. A saying of the Prophet Muhammad (Peace Be Upon Him) mentions that {God is beauty and He loves beauty}. Faith has been the driving force that influenced the early Muslims to beautify their environment.

One of the fundamental goals of design has been the aesthetic of the creation of buildings. It is becoming increasingly clear that closer acquaintance with Muslim architecture in general and with the artistic combination of Islamic principles and architectonic form in particular will help many Muslims to keep the aesthetic qualities of their universal Islamic consciousness, their sense of identity and their sense of direction. Therefore, the Islamic creativity of composition of the muqarnas, as it concerns aesthetic harmony and configuration, bringing together all the elements of composition and proportion, has led to the surfacing of the muqarnas as an aesthetically interdependent formation.

In the Muslim world, the adoption and application of a model which combines the Word of God, geometrical expressions and repeat decorative verses or patterns in the architecture of the mosque has not only created a set of changeless Islamic principles but also a system of architectonic forms. The same system of a unique faction of the

muqarnas attracts our perception through the immediate sensible beauty and attracts between lines and arches in the formation that we can feel, think and be aware of through the shaping and the creativity in the diversity of forms, depending on different designs of muqarnas and the use of different type of the muqarnas.

Internally, the same agreeable consistency and harmonic arrangement of the different parts of the muqarnas can be also achieved, which embellishes and beautifies from the inside. Originating in simple geometric shapes, this can be formed and refurbished in the future designs of muqarnas in very diverse and vital forms. For the Muslim artist the evoking of thoughts of admiration and sent appreciation and admiration does not stop at one point, but moves from one point to another, through suitable forms that are commensurate with the applied functions and purposes, so the measurable beauty can match those factors that enter into the restructuring and contribute to its success in achieving the intended purposes.

The Muslims were great lovers of beauty for everything; "beauty of shape, beauty of intricate design and beauty of colour and their works of art combined grace with delight" (Pickthall, 1927, p.73). Using the principles of the enhancement and beautification of the Earth (*tahsin -al-ard*), they created concrete symbols to enable matter to receive the spirit of the Creator in the form of the Word of God made visible.

The combination of Islamic architectonic and muqarnas forms should be regarded as the most important element in Islamic art, for when the symbols and principles are

proportionately balanced, the equilibrium usually creates beauty and perfection that would not otherwise be possible. The beauty of a thing, says al-Ghazālī (1058-1111) lies in the appearance of that perfection which is realisable and in accord with its nature (*fitrah*) and where all possible traits of perfection appear in an object, it presents the highest degree of beauty. He wrote in ‘Mishkat al-anwar’ (The Niche of Light), “The eye perceives the outer and the surface of thing, but not their inner essence; moreover, it perceives only their shapes and their forms, not their real nature”. (Ghazālī, 1981, p. 41). For instance, when they say “this is beautiful to the eye”, they mean that their personal experiences have emotionally influenced their judgement; therefore this object has become aesthetic irrespective of the facts.

Ibn Sīnā, wrote in “Kitab al-naja”:

All beauty which is suitable and goodness which one perceives (*kull jamāl mulā'am wa-khayr mudrak*), that one loves and desires (*mahbūb wa ma'shūq*), the principle of perceiving them (*mabda'idrākihi*) relies on the senses (*hiss*), imagination (*khayāl*), the estimative faculty (*waham*), conjecture (*ẓann*) and the intellect (*'aql*). (Ibn Sīnā, 1985, p.282).

Also, beauty and ugliness were as much a part of classical Arabic philosophy (*falsafa*), as they were of the Christian thought of the Middle Ages.

Beauty and ugliness are primary and elementary universal notions within the field of aesthetics which, we must remember, began in Greek philosophy with Plato and Aristotle. (Gonzalez, 2001, p.5).

Ibn al-Haytham's treatise Kitāb al-Manāzīr (The book of optics<sup>viii</sup>) explores vision and expounds the basic conditions required for human beauty of proportionality:

Proportionality (*tanāsub*) alone may produce beauty, provided that the organs are not in themselves ugly, though not perfect in their beauty.

Thus, when a form combines the beauty of the shapes of all its parts and the beauty of their magnitudes and composition and the proportionality of part in regard to shape, size, position and all the other properties required by proportionality, and moreover, when the organs are proportionate to the shape and size of the face as a whole-that is perfect beauty. A form that has some of these properties to the exclusion of others will be considered beautiful in accordance with what it has of the beautiful properties (al-Haytham, vol.1, p.205).

As in this excerpt from the philosophical text, these examples show an awareness of the functional and aesthetic aspect of architecture, but how this aesthetic of functional elements in turn influenced architecture is a question that has not yet been suitably investigated. Architecture is thus a mirror that reflects the civilisation prevailing through the ages, including its adaptation to nature. Through this any small part of a building has a symbolic meaning. Wali claims that people have unique worlds of symbols and meaning. Their life is under the control of these symbols, especially in connection with the collective activities shared by those people (Wali, 1995).

#### **4.6.1. Social and cultural dimensions**

Social institutions have their basis in the culture that people share as members of a community or society. So they are cultural phenomena. Culture is what makes human beings distinctively human. It consists of the beliefs, ideas, sentiments, and symbols that people share. It is a patterned system of symbols that mediate and regulate communication (Parsons, 1951).

Culture contains the whole body of knowledge that people have in their minds as ideas and values that provide them with general principles for action, rules of



behaviour, and legitimating beliefs. Islam lays emphasis on many values for the good of the Muslim community and humanity in general. These principles address unity, equality, knowledge, obedience, co-operation, solidarity, community, honesty, purity, cleanliness, preserving nature, and many other sacred values.

Islam puts much emphasis on community life. Both the revelations of the Qur'an and Islamic tradition consider the social life of humanity and the ethics and mechanics of human society. This societal focus is not secular; but ordering the society to act along ethical lines prescribed in revelation, to enter into a more proper relation of human beings with God (Hooker, 2006).

Islam emphasises that there are certain primary relationships governing Muslim society, stemming from the Muslim's belief and his relation to God. These relationships are bound by laws in the form of incentives, rights and duties to maintain the cohesiveness and unity of the community. Particular emphases are laid on individual relationships, regarding man as the nucleus of the society, whose relation to others can formulate an overall view of the entire community (Kaki, 2000).

The culture of a society is an abstraction that is identified from the content of individual minds and the artefacts that people produce (Linton, 1945). Culture not only has a subjective reality, but also has an objective reality as a collective representation. This reality is of a system of shared values and ideas and not of a social or group mind. Collective representations are regular, general, and enduring

within a society, as externalised by the individuals who perceive them as objective and external facts.

In Islamic society and culture, the *Ummah* (nation) is formed by the threefold consensus of its members: consensus of the mind, consensus of the heart and consensus of arms. The *Ummah* is formed from the consensus of minds in that members of the society share the same view of reality. It is formed from the consensus of hearts in that all members share the same values. It is formed from the consensus of arms in that all members exert themselves to actualise or realise their values (Hooker, 2006).

The relations among the elements that make up a culture are not relations of 'real interconnection', of causal or functional connection. The coherence of a culture is a matter of the 'internal relation between meaning components' (Habermas, 1987). These internal relations are those of logic, rationality, and stylistic resemblance. A particular scientific discipline, for example, comprises a network of concepts, propositions, models, and laws that stand in meaningful and often logical relations to one another.

Social institutions are cultural phenomena, and social structures are embedded in the institutional pattern. Similarly, symbols are products of the imagination of mankind and enable people to make abstract ideas, original patterns and to manipulate vital information about various phenomena in the environment features. This finds universal application in all fields of human existence, and at the same time, the

language of the muqarnas is reminiscent of the basic unity of the creation, and therefore they are instrumental in providing the Muslim with a consistent and meaningful physical environment.

The objects of Islamic art are a comprehensive and meaningful human environment, combining architecture, interior decoration, furniture, books and many objects of daily use. While the muqarnas' aspect corresponds to the direct responsibility of man to 'Allah', the Lord of heavens and earth, the way pre-existing muqarnas are adapted, transformed and combined clearly shows an inherent unity of thinking and a common approach to the art and science of designing buildings, and refers to the product of a design or act of designing as well as the artistic traditions. It refers to the overall structure of the system, which is the idea that architecture embodies a coherent set of organisational principles and objectives guiding the design of each aspect of a complex structure. The author's intention is to contribute to an awareness of the significance of the muqarnas for nurturing and transforming the cultural identity of Islamic heritage with a contemporary up-to-date view, which will help artists and architects in their profession to make it more appealing to contemporary art.

#### **4.6.2. Unity**

This research was inspired by the need to address the muqarnas in technical terms to understand the idea of the artefact of Islamic decoration, and also as an expression of the unity of society. Unity is an Islamic contribution, being very strong in Islamic

philosophy and in spirituality. The notion of unity is one of the main principles of Islam, which is, in a sense, an expression of the western philosophy of holism.

Islam has a holistic worldview, believing that everything in the universe was created by God, the sole creator. This is the basis of understanding unity. Islamic philosophy sees the world as one united whole, integrating between objective and subjective aspects. Islamic philosophy belongs to a unified vision that interrelates all regions of knowledge. "*Hikma* (wisdom) is the gnosis where faith and reason holistically meet and come to a harmonious solution" (Nasr, 1967, p.19).

Islam strongly emphasises that unity-oneness is the basic fundamental assumption. It forms the basis of styles of Islamic art and art in general. When examining the relationship between Islam and art and architecture through a holistic perspective, it should be realised that Islam emphasises the notion of unity that all elements together create an architectural form, including space, shape, light, colour, and matter, rejecting sharp distinction between secular and sacred architecture (Nasr, 1971, pp. 19-37). Throughout Islamic history the principle person was the *hakim* (wisest). He was the one who settled the unity of sciences to transmit them clearly to students.

The notion of unity is also emphasised in the five pillars of Islam. It was, originally, evoked through equality, that all people feel they are equal to each other in their rights and duties, which will automatically create a sense of unity between them and unify the whole society into one strong body. Prayer (*al-Salat*), in particular, being a significant pillar, is the rhythmic repetition of spirit, which integrates the Muslim

into the way of realisation and continuation. It is like the most vital process of life, the beating of the heart. It also denotes the consistency of architecture with its overall architectural, social, and cultural environments. Variety within unity is one of the distinguishing features of Islamic architecture, revealing a strong disposition to develop, innovate, and create.

The function of the “organic” unit can be distinguished at various levels, such as the dual use of the muqarnas; structural and ornamental. Symbolically, this integration may be seen as an image of the unfolding and retraction of the created world as often evoked by the *ayat* (verses) of the Qur'an. The author's intention is to transfer the typology and symbolic meaning of the muqarnas through the computer software into contemporary use for architecture and art.

#### 4.6.3. Cosmology

There is another term which had the same definition of the aesthetic and symbolism of the muqarnas – cosmology. Cosmology is derived from Greek *kosmos* (universe) and *-logia* (study), and is the study of the universe in its totality (Vincent, 1981). Ancient societies of the East are known to have always been religious. The most significant feature of these societies is their holistic interpretation of the world; to suppose that everything in the universe has a sole creator is the main foundation for perceiving it as a single unity. This also applies to Islam, as it is argued that existence has always been considered as a unified whole, namely, *Wahdat el-Wujood*, which means ‘the unity of existence’.

Accordingly, the cosmos indicates the divine principle and so does man, and man is himself closely associated with the cosmos. He is the microcosm and, like the cosmos, reflects the meta-cosmic reality (Nasr, 1971). In other words, there is no such division between people and the universes, where people themselves, as a part of the universe reflect the divine. Therefore, the universe and its container, being associated to God, are a unique sacred united whole. Products in space are limited tectonics in infinite space. Consequently, on a plane or in the space of the muqarnas every detail becomes an individualised independent tectonic. A group of muqarnas, individualised tectonics with equal importance in relation to infinite space, obviously creates an additive, cumulative mass.

The issue of the unity of the universe was also raised by Capra, who said:

Although various schools of Eastern mysticism differ in many details, they all emphasise the basic unity of the universe which is the central feature of their teaching. The highest aim for their followers is to become aware of the unity and mutual interrelation of all things, to transcend the notion of an isolated individual self and identify themselves with the ultimate reality. (Capra 1983, p.29).

One of the major schools of Eastern mysticism was related to the teachings and principles of Islam, the grounds of which are oneness, wholeness and unity.

Gonzalez was one of the pioneers in introducing the muqarnas as the general visual context:

They emanate a conceptual language related to the particular notion of the poetic and oceanic marvellous, derived from 'the astral imaginal', hierarchically distinct from the 'heavenly or metaphysical imaginal' in the superior degree. The muqarnas language is naturally linked to the

universal metaphysical signification as a metaphor an Islamic cosmogony. And whether they concern one or the other architectural configuration, in accordance with this overall signification, the conceptual geometrical proposition shape visual space of mathematical abstraction which are destined to shift the perception and the aesthetic appreciation from the sensitive level of corporeal existence to the cognitive level of the mind, the intellect and the spirit. They are phenomenology's of the spirit that complete the phenomenology's of the senses the phenomenology's of the soul, respectively constituted by kinetic and the imaging geometrical proposition. (Gonzalez, 2001, p.115).

The geometries in Islamic architecture are symbolic, and the patterns occur everywhere, from the macrocosmic to the microcosmic level. Triangle, square, circle and hexagons create their own proportion systems (Mann, 1993, p.124). For this reason, 'visual consciousness' in Islamic art is also a form of 'cosmic consciousness'. Cosmic principles therefore make the perfect circle, square and triangle a visible space that can be divided into equal unit parts to create architectonic form. Architectonic forms are results of a combination of geometric patterns in a numerical system and the muqarnas constitutes a fusion of plane geometry and the science of numbers. This practice developed into a rich system of intricate ornamentation that followed the spread of Islamic architecture.

#### **4.7. Conclusion**

This chapter started by offering a theoretical interpretation of the structuralist approach, and outlined some concepts of the identity and structure of the muqarnas from the point of view of different scholars, in order to formulate a general definition of the concept. It also explored the relationship between structuralism and other concepts.

The studies in this chapter also attempted to demonstrate that issues of identity within the thinking of structuralism are relevant to the muqarnas. However, the aim was to deliver a number of interpretations of structuralism that make distinctions between deep structure and surface structure, and to identify the process of transformation that translates one to the other. Structuralism is useful as a tool for discussing the elaborate and epigraphic carvings on the walls of Islamic buildings, and also in modern computer graphics or visual art.

Identity has been considered significant by many philosophers. The identity of the muqarnas comes from maintaining the surface structure through ornament and geometry, which is an expression of laws embedded in the deep structure.

Identity and transformation are therefore very important concepts in this thesis about the muqarnas. Identity comes from maintaining the function, laws, and roles embedded in the deep structure. Therefore in the computerised version the author has aimed to maintain identity, but not in a superficial way.

It is hoped that this chapter has made clear the basis of transforming the muqarnas using the computerised version, which emphasises both the autonomy of single elements and the inclusion of individual units within larger units. The result is argued as perfect balance between the “part” and the “whole”.



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i - Ujam, F. (2006) "Locus architecture outline", School of Architecture, Edinburgh College of Art.

ii - Ujam, F. (2007), in an interview about a number of western philosophies, conducted for the purpose of the research.

iii - Epistemology is another branch of philosophy that examines the nature of knowledge and seeks to determine the limits of human understanding. It includes issues about how knowledge is derived and how it is to be validated and tested (Hutchinson Encyclopaedia, 1999).

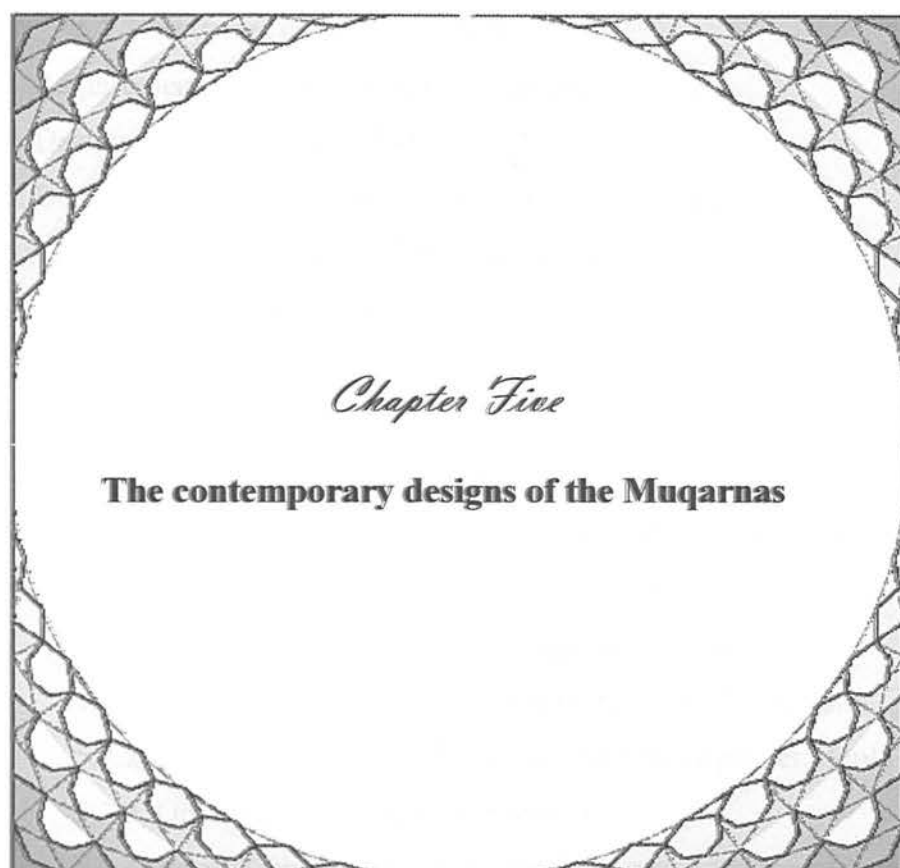
iv - The Manifest (Zahir) God becomes the reality that en-globes all, that "covers" and "encompasses" the cosmos. In this view, (Nasr, S.H. Science and civilization in Islam, p.93, 1985).

v - The Hidden (Batin), this can be regarded as a symbol of the microcosm of man, in whom the physical is the most outwardly manifested aspect and his spiritual nature the most hidden. (Nasr, S.H. Science and civilization in Islam, p.94, 1985).

vi - Islamic ornament is a reflection of a Muslim's transcendent beliefs about objective life, i.e. existence, thus on his behaviours, attitudes and art.

vii - Floral ornamentation was transferred to Islamic architecture from Sassanian and Byzantine styles.

viii - The first three volumes of this seven-volume treatise were translated with commentary by Abdulhamid I Sabra, *The Optics of Ibn al-Hytham*, vols. 1-3, On Direct Vision, 2 vols (London, 1989).



## **Chapter Five: The contemporary designs of the Muqarnas**

### 5.1. Introduction

### 5.2. Applying designs using the software

#### 5.2.1. Aim of the software

#### 5.2.2. Software development methodology

#### 5.2.3. Software development tool

### 5.3. Requirements of the Generator of Muqarnas software

### 5.4. Design of the Generator of Muqarnas software

### 5.5. Development of the Generator of Muqarnas software

### 5.6. Testing of the Generator of Muqarnas software

#### 5.6.1. How the Generator of Muqarnas software system is used

#### 5.6.2. Accuracy of the Generator of Muqarnas software through use of

### AutoCAD

#### 5.6.3. Use of the Generator of Muqarnas software

##### 5.6.3.1. The Generator of Muqarnas from types of muqarnas

##### 5.6.3.2. The Generator of Muqarnas from text Alphabet Mould

### 5.7. Implementation of the Generator of Muqarnas software

#### 5.7.1. Apply Generator of Muqarnas from types of muqarnas

#### 5.7.2. Apply Generator of Muqarnas from text Alphabet Mould

#### 5.7.3. Organising the muqarnas views

#### 5.7.4. Apply Generator of Muqarnas from generated samples

#### 5.7.5. Using the program tools

### 5.8. Conclusion of Chapter Five

### 5.1. Introduction

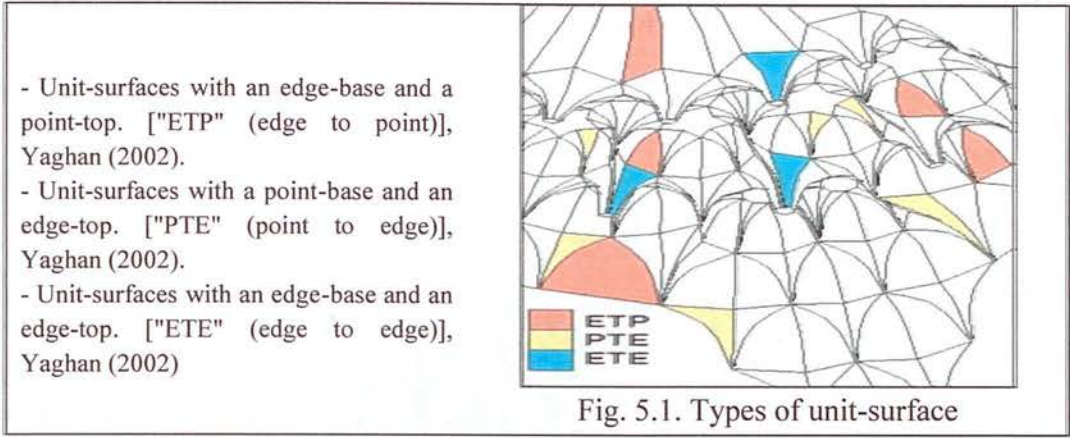
As mentioned in the previous chapter, the muqarnas passed through a process of transformation involving aspects of ornamental design. This chapter is concerned with examining the process of transformation in terms of the image of the muqarnas. It is an ongoing process of developing some practical concepts of designed products based on the software program of the muqarnas developed in the course of this research.

The literal review by the author on Islamic art and architecture were disseminated articles or conference papers addressing only their visual aspects. Many of researchers and artists have treated muqarnas with many aspects, such as historical, technical side and using software. A number of previous muqarnas software programs have treated the use in the performance of the muqarnas into a specific design or specific plan. These researchers also treated this subject as a topic of subsidiary within the overall support of the research study and references in this subject area. Therefore, they have undertaken a number of detail investigation of the muqarnas within the broad research objectives, and decodes historical muqarnas in history according to the geographical origin.

The current study of the Generator of Muqarnas program is present in depth in its explanation of the data collection process and sample design as a tool; based on volumes of information about aesthetic preference and various ornamental designs. Further it attempted to create numerous mathematical probabilities and possibilities of muqarnas design, showing an unlimited creativity by the use of maximum limits of the benefits of software facilities, while the previous muqarnas software programs used minimum limits of benefits of software facilities.

The author has developed a framework that can run the muqarnas elements in a space with the elaboration maths framework. He translated the formulation of each element's muqarnas shape into a programming language, in order to generate these shapes automatically., Also to have them ready for use in the form of computerised two-dimensional and three-dimensional drawings, as well as to move, rotate, or stretch them, using the CAD as a tool. This process can also can be applied to any AutoCAD command on the generated shape, e.g. Copy, Mirror, Render, etc. The Generator of Muqarnas program is based on the original muqarnas types (Shami, Baladi and Alphabet mold). It also allows for efficiency of working with materials, textures, colours and light, to make this objective much simpler for people to be really very creative by using this facility to structure the whole construction of muqarnas, by moving the parts and play with forms. This allows architect and artist to calculate alternative designs or to be aware of the significance of drowning the atheistical quality in the architecture, through the modern technology of the computer.

Greater elaboration of the previous muqarnas software programs has offered analysis and relevant book "MUQARNAS", Yaghan (2002), created a software programmed for creating muqarnas, and also proffered a special type and a short on-line course. The author attended one of his courses in Saudi Arabia, in King Abdulaziz University (College of Engineering and College of Environmental Design), in Jeddah, in 2001. Yaghan looked up the projection of muqarnas as complicated and as very difficult to understand. He has used visual function to provide the gradual transition between two levels, two sizes, and two shapes with the types of unit-surface with an edge and a point (Fig. 5.1).



The muqarnas consists of orderly horizontal and vertical joint layers (Fig. 5.2) stacked one on top of the other, connected via their bases and tops and separated by layer joints that are then filled by roof patches which are like stars (Fig. 5.3).

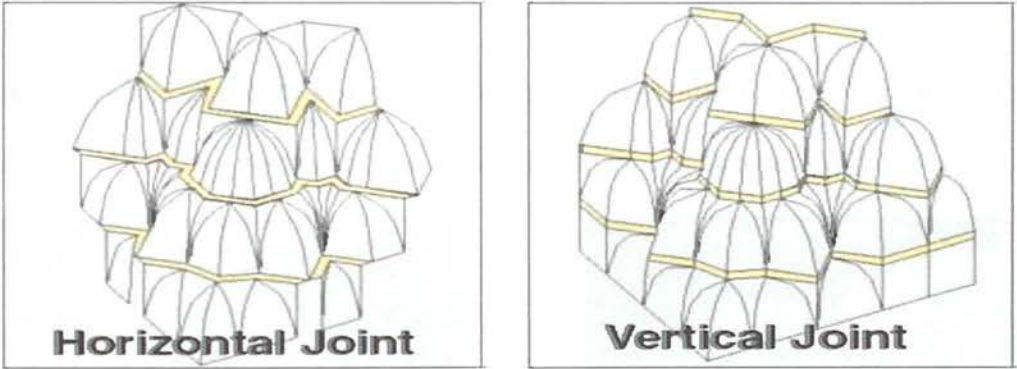


Fig. 5.2. Horizontal and vertical joint

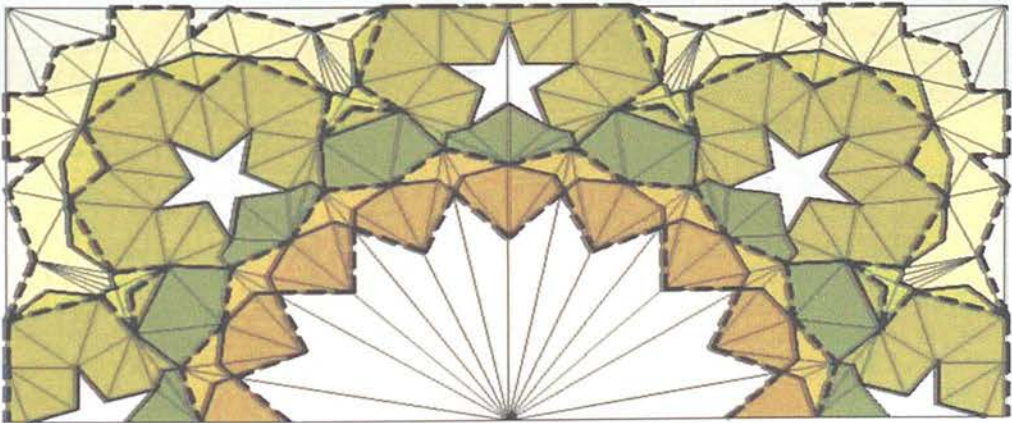


Fig. 5.3. Umit-surface plan by Yaghan (2002)



Then Yaghan tried to separated the units into plan of roof, patch layer and later-line (Fig. 5.4).

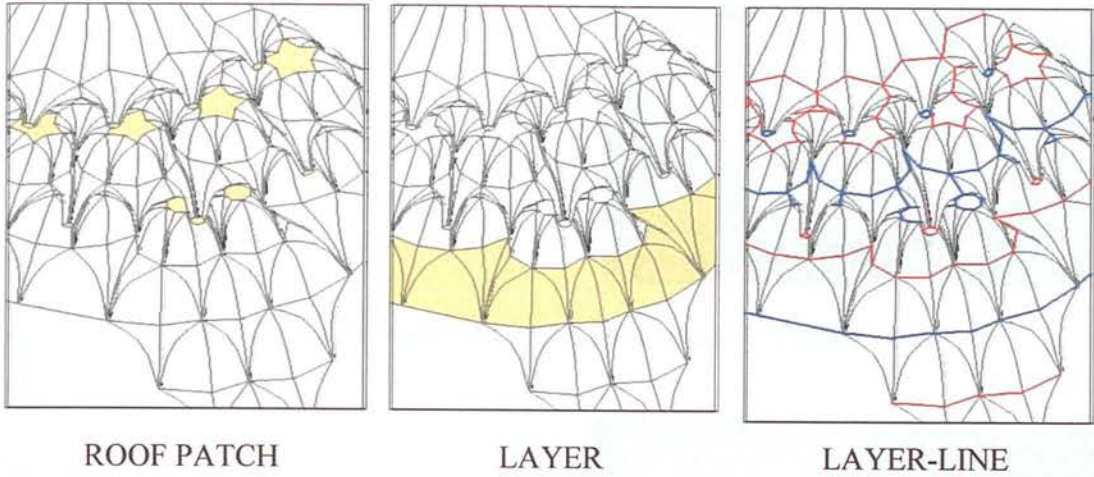


Fig. 5.4. The plan of roof patch, layer and layer-line

Some selected examples of assemble of the muqarnas units showing their realisation in several architecture elements, such as whole building and single column (Fig. 5.5).

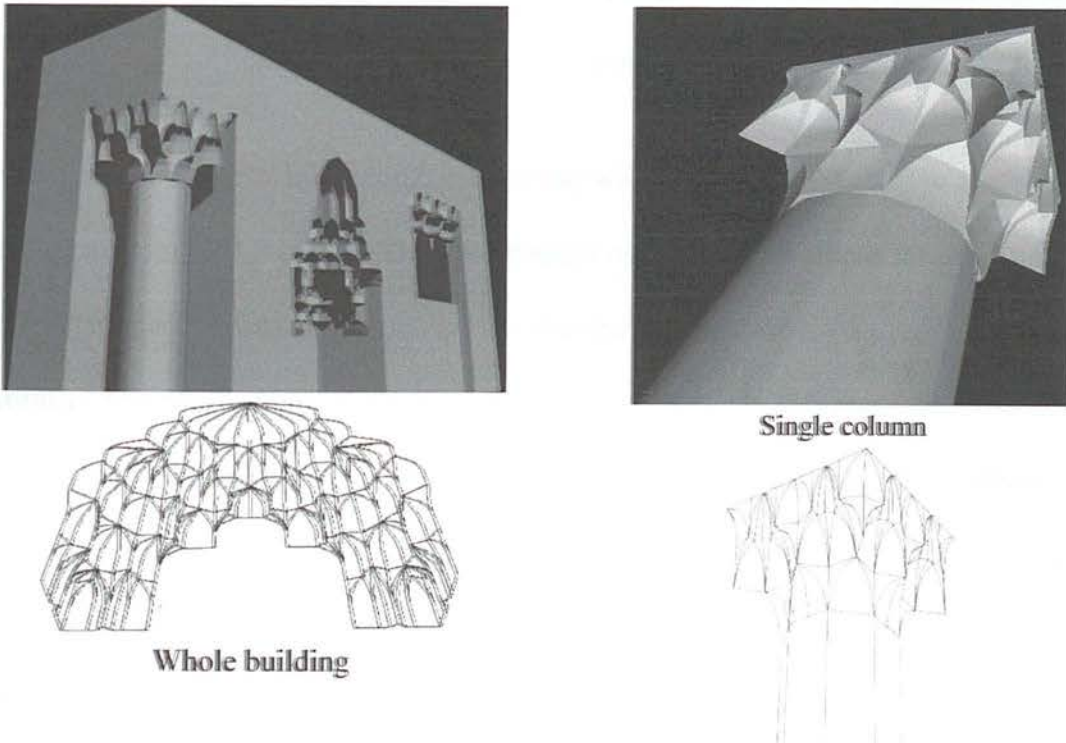


Fig. 5.5. The example of assembling the units of muqarnas as whole building and single column.

The another assemble examples of the muqarnas units in single cornice and portal (Fig. 5.6 A and B)

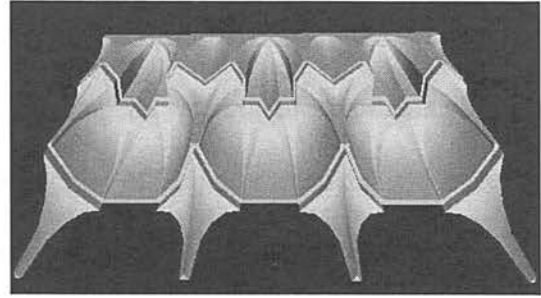
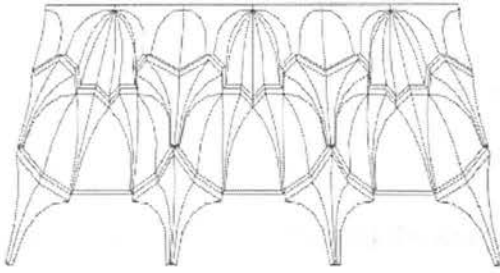


Fig. 5.6. A. The example of single cornice by Yaghan (2002)

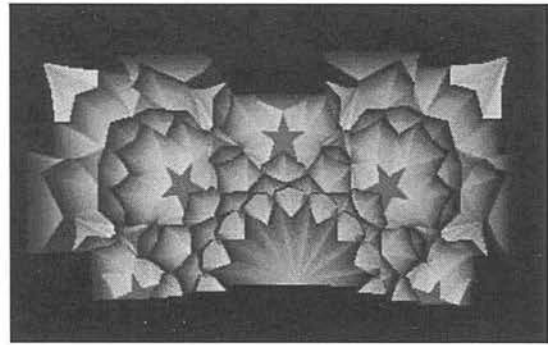
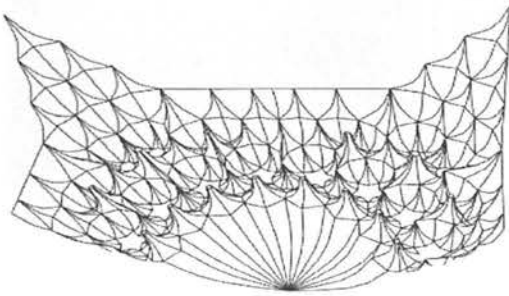


Fig. 5.6. B. The example of portal by Yaghan (2002)

The author was inspired by the muqarnas work, when he enrolled on online course by Dr. Yaghan's in 2001 to 2005. The contribution of Dr Yaghan's upon algorithms, is that he imagined a third dimension, and the requirement of corbel support of the basic decorative muqarnas. While the author was unable to focus in Generator of Muqarnas program, his research question was mainly focused on the elements of fundamental types of muqarnas. Yaghan has recorded his research by secure (lock) code-system, however the author has open source code-system, as he is intending to make the muqarnas application more deeper into the building decorations and in a rich spatial form and ornamental format, with sample design as a tool, based on volumes of information about aesthetic preference or contemporary design.



The other research by the Hamsen and Jungblut (2007) has also shown the most important combinations of elements in tiers. They give a two-dimensional plan from which it is possible to determine directed graphs, after adjusting some free directions manually, and three-dimensional models can then be generated automatically. However, this may be due to focus on a reconstruction of Seljuk muqarnas, and have used graph theory for drawing the muqarnas, using algorithms to transform them into specified shapes and forms (Figs. 5.7).

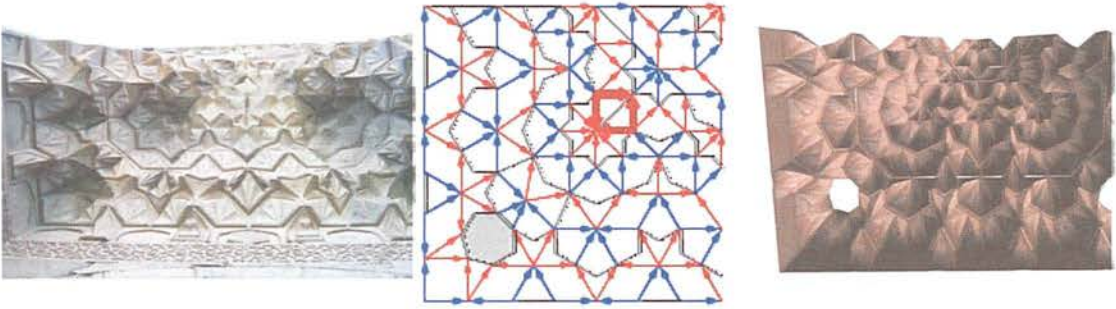


Fig. 5.7. View from underneath the portal section at Sultan Han Kayseri (1232–36), and how Hamsen and Jungblut have drawn the graph and display by computer.

Hamsen and Jungblut have drawn a basic muqarnas cell: a geometrical ornamentation and how they can be combined in a tier (row). (Fig. 5.8).

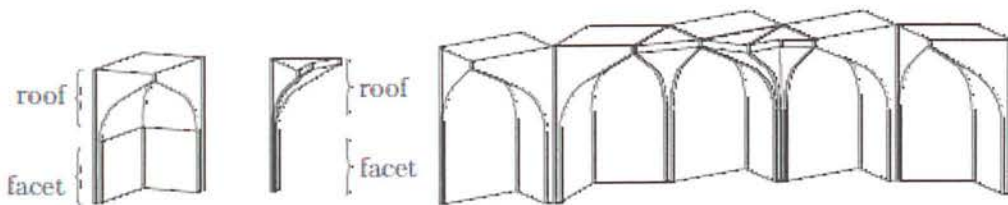


Fig. 5.8. From left to right is shown a basic muqarnas cell, an intermediate element and how they can be combined in a row.

Also, they have drawn a basic muqarnas cell and intermediate element with upward directions (left) and their 2D projection (Fig. 5.9).

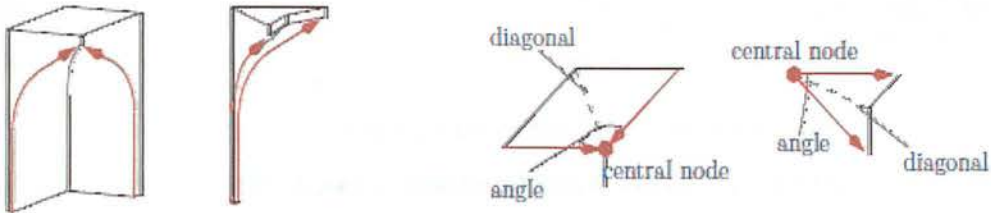


Fig. 5.9. Cell and intermediate element with upward directions (left) and their 2D projection.

The another assemble examples of the cell of staircase, comprises two cross vaults (roof and facet), which create three barrel vaults side by side, with the four barrel on top, in the same structure of the graded axis or orthographic view (Fig. 5.10).

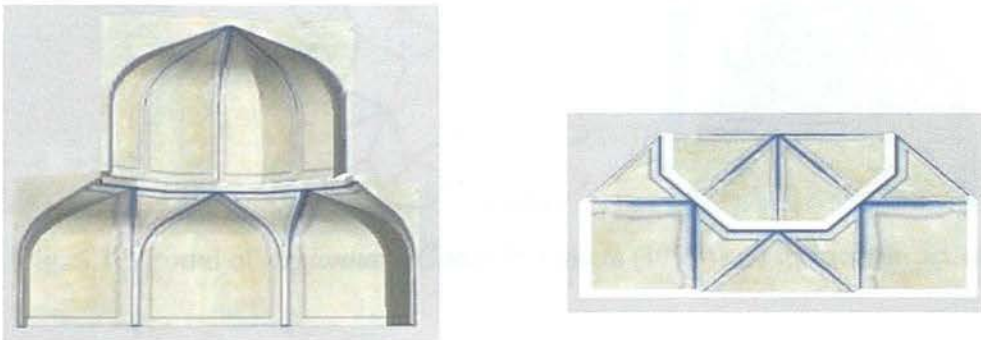


Fig. 5.10. Example of cell of staircase plan: switches to the orthographic view

Also, they have automated reconstruction: From 2D plans to 3D ornaments showing a hole instead of an element (Fig. 5.11).

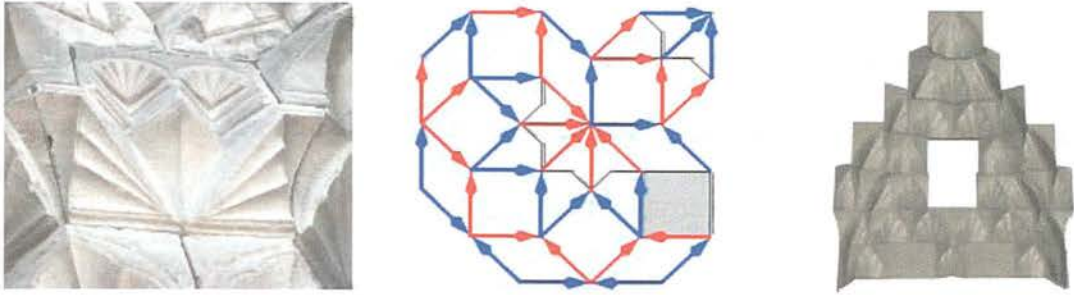


Fig. 5.11. Entrance portal of the Medresse in Kayseri.

The picture on the left shows a central element involving two tiers. Half of this element corresponds to the grey-coloured square in the directed sub-graph showing only half of the symmetric niche (middle picture) by Hamsen and Jungblut (2007).

Hamsen and Jungblut have selected examples of Seljuk portals and have displayed reconstruction by computer (Fig. 5.12).

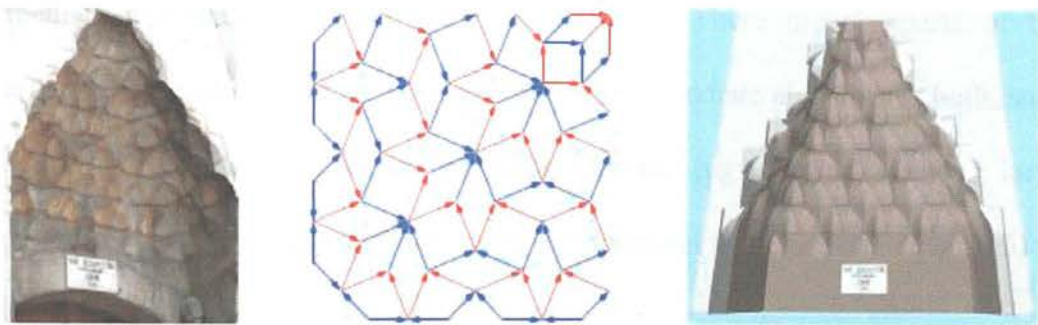


Fig. 5.12. Portal of *Arslanhane Camii* in Ankara (1290) and its reconstruction

Hamsen and Jungblut have recorded in their research a graph of muqarnas work which could be displayed by computer **that has received the author's** appreciation particularly for making him understand in details the basic muqarnas cells as a geometrical ornamentation and how they can be combined in a row; such as orthographic of the cell, and automated reconstruction from two-dimensional plans to three-dimensional ornaments models. It is possible to determine directed graphs, after adjusting some free directions manually, and then be generated automatically. The



author has addressed this in Generator of Muqarnas Program, by adjusting directions manually in the generation of the muqarnas types or alphabet mould automatically. This process can be used in single component element or group component elements of muqarnas, which allows the user to create muqarnas units and comparing with software facility to represent clear formative creations. Furthermore this process can play with units and assemble them to produce the final feature over all features where it can fit in corners, columns, ceilings, arches, domes, or in any part of the building.

Another research program by the Dold-Samplonius (2003), used basic geometrical forms and descriptive details from *Bastam in Al-Kashi* architectural models in Muqarnas Visualization in the Numerical Geometry Group (al-Kashi, Centaurus, 193–242). The plane projections of the two different types of elements, cell and intermediate element, are simple geometrical forms. There are six parts of the muqarnas, which can be used as a cell element or intermediate elements or both, such forms that can be used are: square, rhombus, almond, jug (quarter octagon), large biped (complement to a jug) and small biped (complement to an almond) (Fig 5.13)

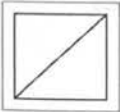
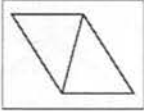
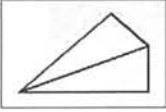
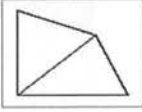
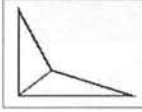
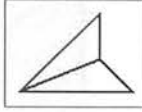
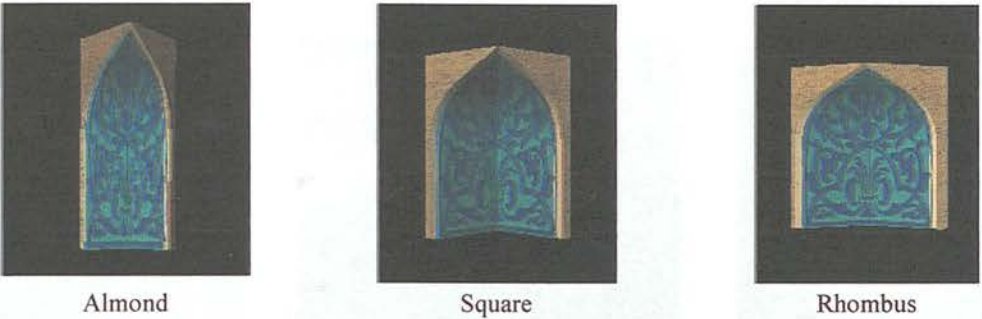
					
Square as a cell	Rhombus as an intermediate element	Almond as a cell	Jug as a cell	Large Biped as an intermediate element	Small Biped as an intermediate element

Fig. 5.13. The plane projection of a simple element is a basic geometrical form.

Dold (2003) has shown the animation of a basic geometrical shape (either cell or intermediate element), with interior ornament of each element and applied render with software facility (Fig. 5.14).



Almond Square Rhombus  
Fig. 5.14. The animation of a basic geometrical shape

Also, she has drawn a correlating plan of muqarnas composition (Figs. 5.15–5.16)

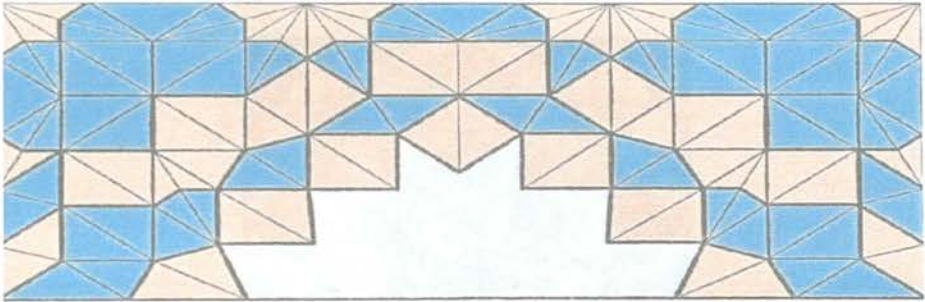


Fig. 5.15. Correlating plan

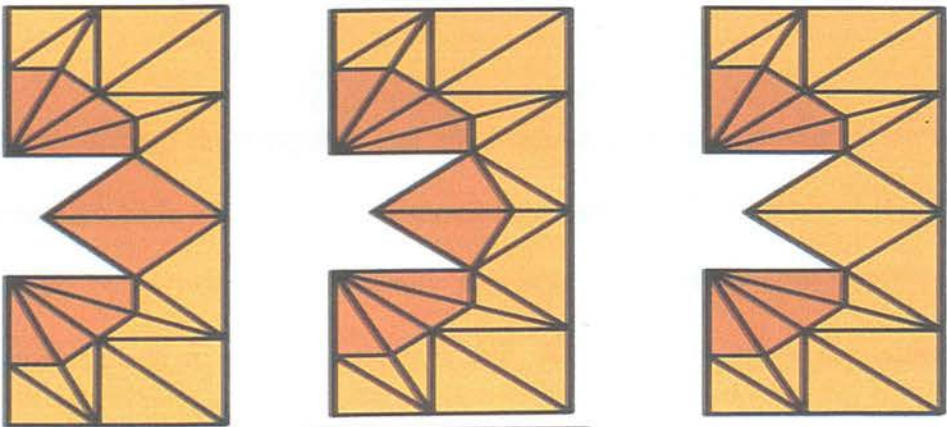


Fig. 5.16. Correlating plan

Dold’s software program has shown the elements constructed according to the same unit of measure, so they fit together in a wide variety of combinations. In his

computation Al-Kashi, uses the *module* of the muqarnas, defined as the base of the largest facet (the side of the square) as a basis for all proportions (Fig. 5.17 and 5.18)



Fig. 5.17. The *module* of the muqarnas elements construction by Dold (2003).

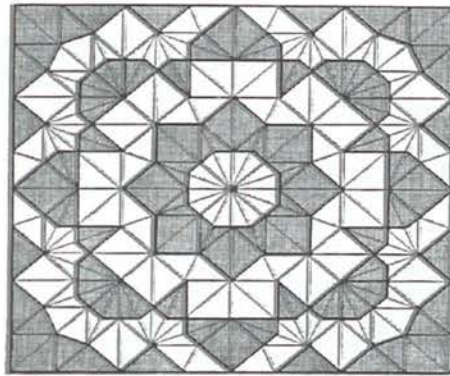


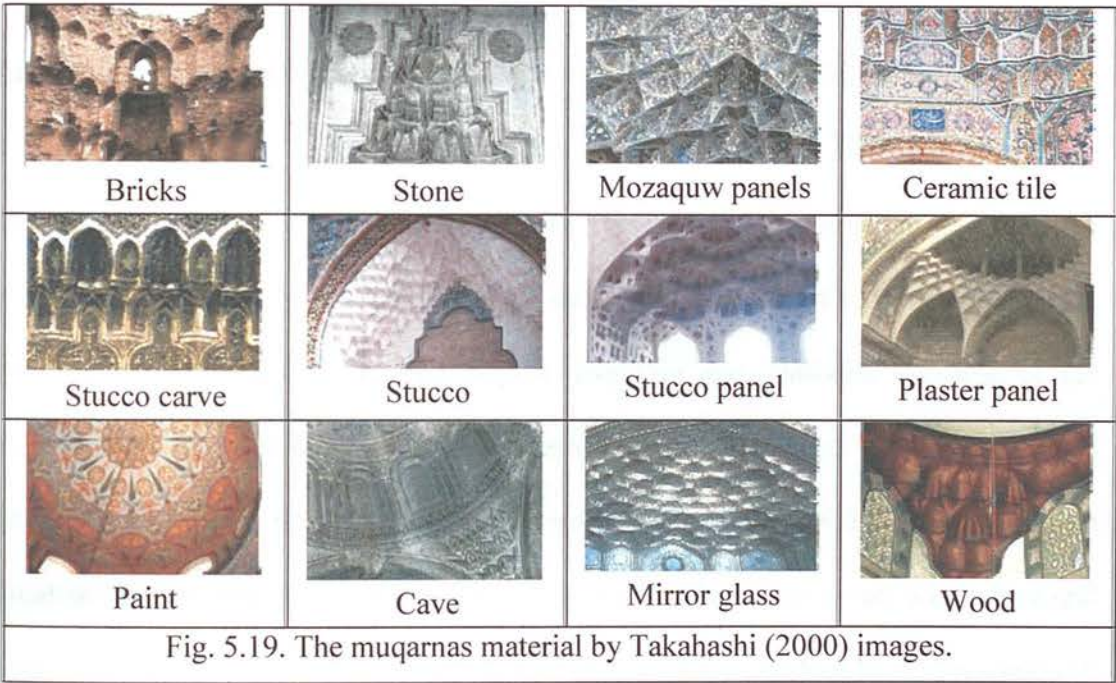
Fig. 5.18. The *module* of the muqarnas elements with chart composition

Dold has divided the muqarnas into six elements as a cell element or intermediate elements or both, and has demonstrated how they can be assembled together and displayed by software. It is actually measures ~~the author's~~ understanding of the sequence related to a basic muqarnas unit. Although the author has addressed in Generator of Muqarnas Program adjusting the muqarnas units by generated alphabet **mold I (7 unite) and alphabet mold II (8 units) by design**. This shall allow the user to create muqarnas units with software facility to represent clear formative creations. It



can then be played with units and assemble them to produce the final feature of muqarnas as the same as realty.

Another research by Takahashi (1973 - 2000), has shown the most important images of around 2000 muqarnas, with many details of the functions and materials, and how they are applicable to their type of muqarnas database. However this may be due to the review on the style of square, triangular and table of muqarnas, with various countries and architect skills. Also he has surveyed the plans of muqarnas, ordered by their geographic and historic relations, and has tended to be concerned with issues of type and material (Fig. 5.19).



Research by Takahashi (2000), has shown the most important images of around 2000 muqarnas, with many details of the functions and materials, and how they are applicable to their type of muqarnas database. The author was impressed with the richness of these images of function and material done in Takahashi's research. This

is seen as useful for the author of a practice based PhD, which allows him to go beyond copying what has been developed historically in other place. The author could obtain these benefits in the same ways that help the architects and designers to use in a very creative and imaginative way. This offers them the freedom to scheme with form and design creatively. This process can be used in the façade, arches, domes, capitals, windows, ceilings, receptions, staircase and a variety of furniture, in the way acceptable with the modern technology of the computer. Example is the comprehensive work for evolution of art and architecture as seen in the historical developments in many Islamic countries, to cover important aspects that will enlighten the reader about the muqarnas.

The previous researchers have written numerous articles and books on various aspects of muqarnas focusing in particular on the design objective. They have valuable reflections and efforts to produce a software versions for new concept of designing the muqarnas. Similarly the author has attempted to describe the design processing program in this research, with the origins, structure and symbolic meaning of the muqarnas. He has also included in his research its transformation for use in modern design without losing its meaning. The potential of this research lies in the ability to visualise data generated from the blocks of muqarnas. To create a user's interface and to convert two-dimensional plans into three-dimensional muqarnas data. The research has focused on producing a wide range of designs in a very simple way which corresponds to the muqarnas method of drawing. The author concluded to avail this opportunity and to make the design of muqarnas much simpler for people to be really very creative by using this facility of structure. This was possible by moving the parts and play with forms. This shall allow architects and artists, who are not necessarily



using complex designs, to be aware of the significance of drawing the aesthetical quality of muqarnas in the architecture, as an innovation.

The author has developed a framework that can run the muqarnas elements in a space with the elaboration of maths framework. When the author started his analysis and configuration of the muqarnas units to the decimal numerical system, the components are 0 1 2 3 4 5 6 7 8 9. Then he exchanged these components to the compatibility and probability of mathematics, from double-digit to a hundred of probabilities, such as, form 00 to 99, i.e. (e.g. 00, 01, 02, 03, ....., 09, 10, 11, 12, ....., 97, 98, 99). For example, when he accomplished the analysis and configuration of Alphabet Mold units of muqarnas, in the Generator of Muqarnas program, (e.g. *Katf* unit, or *Moftuha* unit, or *Mesdouda* unit, or other units), the author was able to create a number of repetition units (Number of repetitive units  $\times$  Number of configurations). Further example, when he intended to generate one unit into software facility, such as *Bouja* or *Serwaliya*; the first step he needed was to sketch this unit to 8 units, and translate the formulation of each element's shape into a programming language. This is in order to generate these shapes automatically, a task which is very complex and easy at same time. It has become possible also to move, rotate, or stretch them, using the CAD as a tool, or to apply any AutoCAD command on the generated shape, e.g. copy, mirror, render, and so on. This can then be applied to any materials, textures, colours, light.

The aim of this chapter is to discuss the basic application programs and the research methods employed in the muqarnas data collection, and the methodology used to interpret it. This will lead to a small software program using AutoCAD to turn the

computer into a tool that solves muqarnas design problems in order to produce a working design solution. This will be achieved by presenting a software program design within which the research brings together a number of designs to create a unified framework for studying the principles of the muqarnas. This application software program may be used as a tool for developing new types of muqarnas designs, using their exact geometric rules, proportional systems, shapes and aesthetic values, and will make them accessible via a simple software interface. The performance of the muqarnas types program will be developed via computational logic (algorithms, dash operations) and programmatically (a database of the rendering and modelling).

This chapter will concentrate on the performance of the muqarnas design processing program 'Generator of Muqarnas'. This program can be used to visualise data generated from the blocks of muqarnas, to create a user interface and to convert two-dimensional plans into three-dimensional muqarnas data. It is aided in finding alternatives to the model (muqarnas blocks) by assessing and having them ready for use, assisted by the computer software, which is able to rotate, turn over, and output the expressed transformations fast and accurately, and allows for efficiency of working with different materials, textures, colours and light.

## **5.2. Applying designs using the software**

The aim of this section is to discuss the findings from the empirical aspects of the transformation of the muqarnas, and depends on establishing the types of muqarnas units in a software program, by using the 'Generator of Muqarnas' program as a tool in order to produce a muqarnas design creation solution

### 5.2.1. Aim of the software

This new software application aims to facilitate a new automatic approach to the design of muqarnas, to develop the ideas and to present the modern muqarnas with creative technology. This program will find alternatives ready for use in the form of computer-generated muqarnas drawings which will help users assess designs, as they are easy to use, saving time and effort.

### 5.2.2. Software development methodology

The methodology of software development focuses on how the aim of producing computer-generated muqarnas drawings will be fulfilled. The author will use the Waterfall Model to examine how the Generator of Muqarnas software can be developed in line with criteria pertaining to the stages of software methodology. He will introduce the process stages of the Waterfall Model (Requirements, Design, Development, Testing and Implementation). Gary's (1999) Advance Waterfall Model is illustrated in (Fig. 5.20).

It allows returning to the previous stage when the need arises but this provision should be used with care. This advantage is important in software developments as it is considered a plus point of this model. It is undesirable to change the specifications of the previous phases. However, this model does allow to provide the flexibility to incorporate important requirements in the development process. (<<http://www.dspace.fsktm.um.edu./Chapter3.pdf>>, 2009).

The author will use this methodology to present his Generator of Muqarnas software.

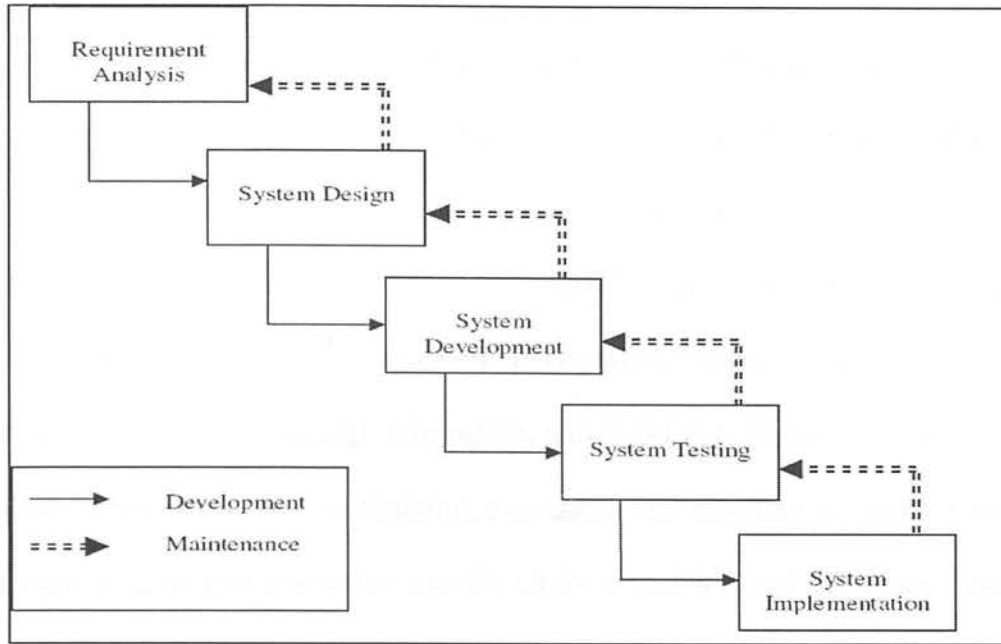


Fig. 5.20. Waterfall Model

**Waterfall Model:** explains that the waterfall model starts with the requirements analysis. This is followed by system design, system development, system testing, and finally system implementation.

**Requirements:** The first stage of the Waterfall Model implemented in this research is the requirements analysis. In this phase, the requirements of the new system are identified. This is followed by the next stage in the waterfall model, which is the system design phase.

**Design:** In this part, the requirements of the project will be translated into a detailed design. The dataflow diagram (DFD) will be used to link the whole system with this specification. As is generally known, the DFD will provide detailed information regarding the flow between the information and the tables involved. This will also give a clearer idea of the tables that are needed.

**Development:** This is the phase where all the designs will be translated into machine-readable coding. The coding should be done keeping in mind future enhancement and system reliability.

**Testing:** The complete software will also be tested based on the functional and non-functional requirements. Each component of the software will be tested separately to ensure error-free software and component integration.

**Implementation:** The system implementation process concentrates on how the developed system will be implemented in the advertisement agency. Gary(1999).

### 5.2.3. Software development tool

The chosen methodology brings many benefits for the final delivery of the development software of the Generator of Muqarnas drawing system. The methodology system is used as general system for the systematic development of display techniques in the project. This approach will create a more scalable system as it models the real world via abstraction. It is a set of sequence instructions and a collection of muqarnas data and information, which tell the computer what to do. It is (Logical Component) built on thinking, expression and planning to create a modern muqarnas. It is designed to solve specific kinds of problems of muqarnas design so the designer can see it from all sides. It uses programming language such as:

- A. **Microsoft Visual Fox-Pro:** a database language used to manage the muqarnas database analysis. It uses process instructions to set up the various muqarnas structures.
- B. **Visual Basic for Application (VBA):** a programming language in the AutoCAD program used to develop the draw and design process.
- C. **Auto Lisp:** It is programming languages in AutoCAD program used to develop draw and design.

The author assigned the task of programming this system to a competent authority ([www.bianoony.com](http://www.bianoony.com), 2005-2009) as the research object was to provide the idea as the model matching with the results of the study analysis, and to create a user interface with which users would be able to edit muqarnas plans. It works together with the AutoCAD program, which is widely used both by professionals and amateurs, allowing high-quality epigraphic types of the muqarnas to be created.

The following sections are meant to provide stimulation from the Waterfall Model, in considering these five stages of forces, and reflecting them in the development of the Generator of Muqarnas software.

### **5.3. Requirements of the Generator of Muqarnas software**

The requirements of the development software to generate the muqarnas drawing system are the following:

- Create muqarnas in terms of quantity and quality: it works with hundreds of thousands of combinations and formations, in a short period of time.
- Create muqarnas in terms of space: it can work in space without limits, as the computer displays the design in three dimensions along the three perspective axes  $x$ ,  $y$ , and  $z$ .
- Create muqarnas in terms of materials: it can illustrate the muqarnas composition clearly and unmistakably in any material or combination of different materials, as well as creating new materials.
- Create muqarnas in terms of colouring and drawing on the unit of the muqarnas, leading to variety and infinity of the art work.
- Create muqarnas in terms of elements: new elements can be used to update the muqarnas and to create a new modern muqarnas identity.

These requirements will be explained in the following section concerning the design of the Generator of Muqarnas software phase.



#### 5.4. Designs of Generator Muqarnas software

The performance of the Generator of Muqarnas software, processing design within AutoCAD program, by using Statement, there is a little of Flow-Charts plan to built this software, as following:

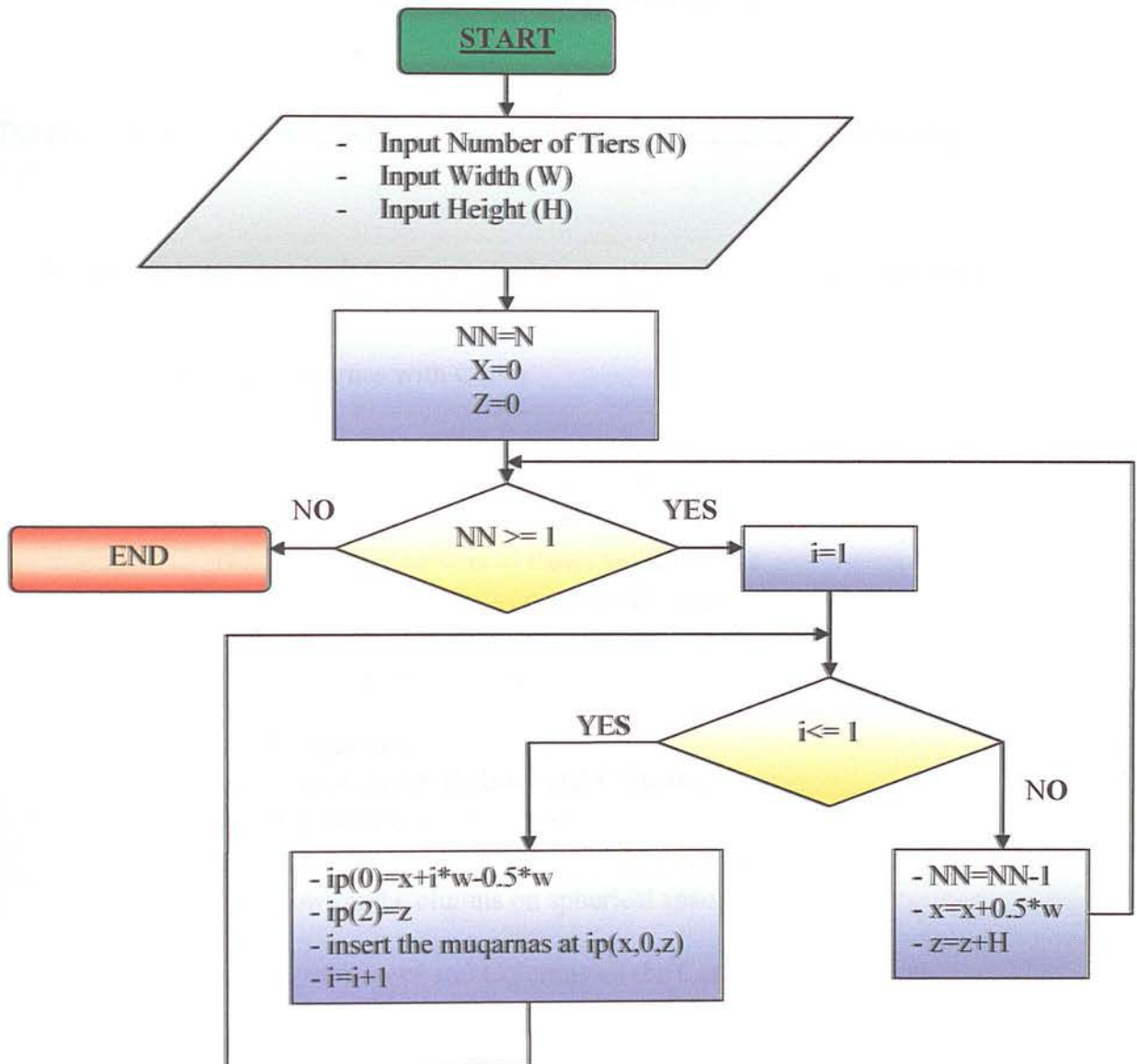


Fig. 5.21. Flow-Charts plan of the Generator of Muqarnas software

COMMENTS:

- ip(0) Represents the value of insertion point at X axis.
- ip(2) Represents the value of insertion point at Z axis.
- ip(1) Represents the value of insertion point at Y axis.
- ip(1) Was not mentioned above, that means it is equal to zero.
- NN Is a variables reflects the reduction of number of units in the next tier.

The processing designs of generator single component of muqarnas, as following:

1. Design muqarnas with Curve or Circle path, depending on angles and rows.

➤ Design muqarnas with Curve.

- i. Design Arc.
- ii. Repeat Arc with rows and Columns.
- iii. Repeat Arc with Circular.
- iv. Three Dimensions of Rows and Columns.
- v. Rows and Columns on spherical space.

➤ Design muqarnas with Circle.

- i. Design Arc.
- ii. Repeat Arc with Rows and Columns.
- iii. Repeat Arc with Circular.
- iv. Three Dimensions of Rows and Columns.
- v. Rows and Columns on spherical space.

2. Design muqarnas with rows and Columns on the Cornice as rectilinear.

❖ Designing Row.

- i. Repeat Row horizontally.
- ii. Repeat Row horizontally and vertically.
- iii. Repeat Row with Circular.
- iv. Three Dimensions Row repeat with layers.
- v. Three Dimensions Row repeat with circular path.



### 5.5. Development of the Generator of Muqarnas software

The coding phase of the design of Generator of Muqarnas software is shown below as VBA code, which is the translation of the previous algorithm into the VBA language will be like this:

```
Sub PlainMuq(N As Integer)
  Dim NN As Integer, i As Integer
  Dim x As Double, Z As Double
  Dim ip(0 To 2) As Double
  Dim H As Double, W As Double

  NN = N
  x = 0: Z = 0: ip(1) = 0
  H = 10: W = 10

  Do While NN > 0
    For i = 1 To NN
      ip(0) = x + i * W - 0.5 * W
      ip(2) = Z
      ThisDrawing.ModelSpace.InsertBlock ip, "MUQ-UNIT", 1, 1, 1, 0
    Next
    NN = NN - 1
    x = x + 0.5 * W
    Z = Z + 0.5 * H
  Loop
End Sub
```

The result will be something like this see Fig. (5.22.)

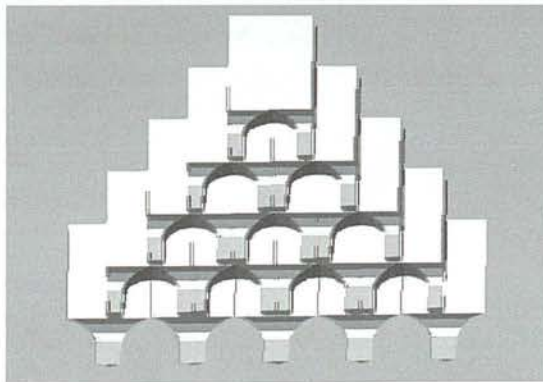


Fig. 5.22. Blocks model of muqarnas on spherical space.

The **Text code** that had written in Visual Basic (VB) language into AutoCAD program, as following:

1. UTILITY procedural assistance to convert a unit of angles measurement

Degree to Radian:

```
Function dtr(Ang)
  Dim Pi As Double
  Pi = 4 * Atn(1)
  dtr = Ang * Pi / 180
End Function
```

2. Generator of muqarnas on a cylindrical formation:

```
Sub Cylindrical Formation OF Muqarnas ()
  "Subroutine to Create a Cylindrical Shape of Muqarnas
  Dim N As Integer
  Dim NN As Integer, i As Integer
  Dim x As Double, y As Double, Z As Double
  Dim ip(0 To 2) As Double
  Dim H As Double, W As Double
  Dim Radi As Double, Ang As Double
  Dim Ang1 'Spread Ang
  Dim Alpha
  Dim CumulativeAng
  "Assign Values to Variables
  N = InputBox("Enter Number of Rows:")
  Ang1 = InputBox("Enter the spread Angle: ")
  W = 10: H = 10 "These values are only for this example
  "Calculations
  Alpha = Ang1 / N
  Radi = W / (2 * Tan(dtr(0.5 * Alpha)))
  MsgBox Radi
  "Loop and Insert the Bloks
  CumulativeAng = 0
  NN = N
  For i = 1 To N
    For j = 1 To NN
      ip(0) = PolToCarX(Radi, CumulativeAng + (j - 1) * Alpha)
      ip(1) = PolToCarY(Radi, CumulativeAng + (j - 1) * Alpha)
```



```

    If i = 1 Then
        ThisDrawing.ModelSpace.InsertBlock ip, "B1-3D", 1, 1, 1,
dtr(CumulativeAng + (j - 1) * Alpha - 90)
    Else
        ThisDrawing.ModelSpace.InsertBlock ip, "B2-3D", 1, 1, 1,
dtr(CumulativeAng + (j - 1) * Alpha - 90)
    End If
Next
CumulativeAng = CumulativeAng + 0.5 * Alpha
ip(2) = ip(2) + 0.5 * H
NN = NN - 1

Next
End Sub

```

### 3. Generator of muqarnas on a plain formation:

```

Sub PlainMuq(N As Integer)
    Dim NN As Integer, i As Integer
    Dim x As Double, Z As Double
    Dim ip(0 To 2) As Double
    Dim H As Double, W As Double

    NN = N
    x = 0: Z = 0: ip(1) = 0
    H = 10: W = 10

    Do While NN > 0
        For i = 1 To NN
            ip(0) = x + i * W - 0.5 * W
            ip(2) = Z
            If NN = N Then
                ThisDrawing.ModelSpace.InsertBlock ip, "B1-3D", 1, 1, 1, 0
            Else
                ThisDrawing.ModelSpace.InsertBlock ip, "B2-3D", 1, 1, 1, 0
            End If
        Next
        NN = NN - 1
        x = x + 0.5 * W
        Z = Z + 0.5 * H
    Loop

```

```

End Sub
End Sub
Sub TestInvertedMuq()
    InvertedPlainMuq InputBox("enter number of rows: ")
End Sub
Sub TestMoq()
    PlainMuq InputBox("Enter Number of rows: ")
End Sub

```

### 5.6. Testing the Generator of Muqarnas software

In the previous section the coding phase of the development of the muqarnas generator system was illustrated. It is essential to check the performance and efficiency of the system and check that it is error free. The following section describes the testing of the system in order to diagnose any space filler and enhance the Generator of Muqarnas software. The author will discuss how the system uses this program, after that he will explore accuracy (correctness), ease of use and usability in the following sections.

#### 5.6.1. How the Generator Muqarnas software system is used

The Generator of Muqarnas program is software based and is used as a tool to create designs, to convert two-dimensional plans to three-dimensional muqarnas data, and to assess alternative designs and have them ready for use in the form of computerised drawings. When the user launches the Generator of Muqarnas program in the computer, the welcome interface window<sup>i</sup> will appear, which proffers the main idea of the program, as Fig. (5.23).

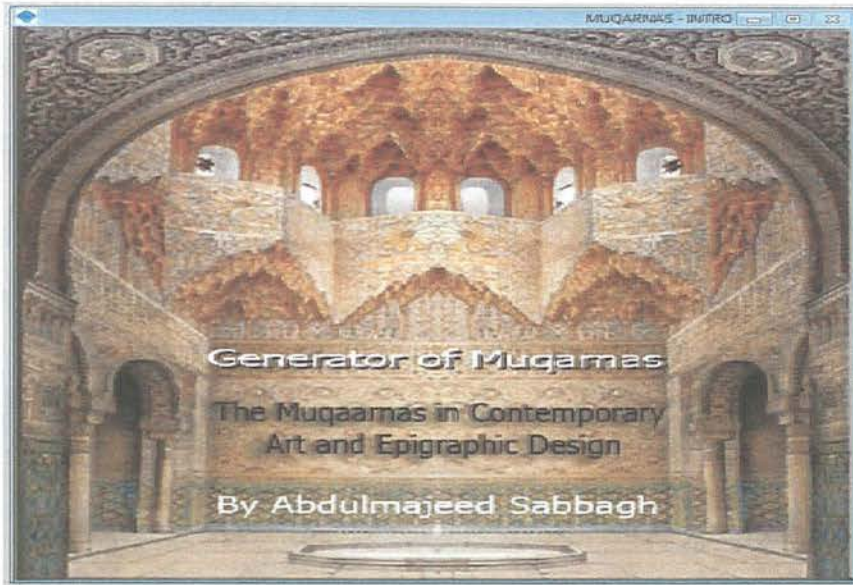


Fig. 5.23. Interface window of Generator of Muqarnas program

Once the interface window has closed, the desktop screen (mine-screen) will start up, offering alternative selections on the menu bar, such as: Research, Muqarnas Types, Muqarnas Generator and Help. Clicking on any of these menus causes a list to appear containing all the commands for that menu, as shown in (Fig. 5.24). Click outside the menu to close.

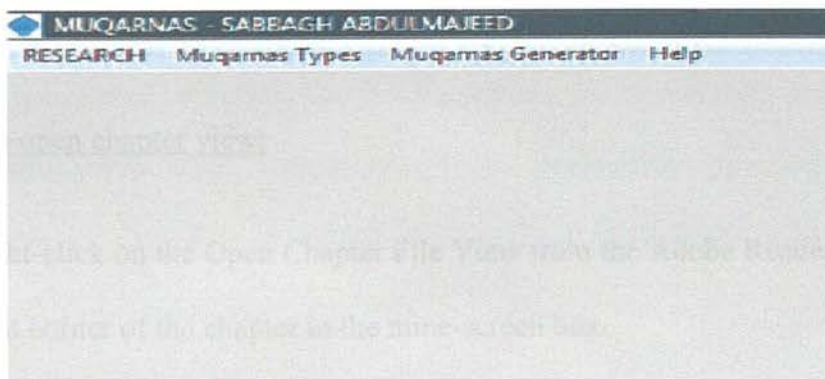


Fig. 5.24. The mine-screen of Generator of Muqarnas program



When the user chooses **Research**, the research view displays the contents of a folder as a list of chapter files from chapter one to chapter six of the current thesis, as shown in (Fig. 5.25). Each chapter is linked with the Adobe Reader program (extension .PDF) files; allowing the user to view chapters and making reading chapters on the screen more comfortable.

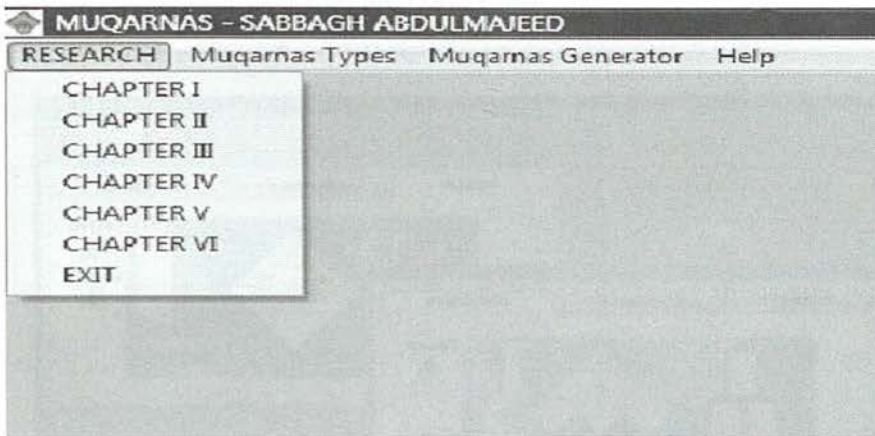


Fig. 5.25. Display Research chapter from menu list

To display open Research view:

1. Click on the Research on the menu bar.
2. Select from display Research choose chapter from menu list One to Six.

To close an open chapter view:

1. Right-click on the Open Chapter File View from the Adobe Reader icon in the right corner of the chapter in the mine-screen box.
2. Select Close Chapter View, click Exit or X in the upper right corner of the menu-bar.

When the user chooses **Muqarnas Types**, the contents of the types of muqarnas are displayed as SHAMI and BALADI type. The software allows the user to work in both two-dimensional and three-dimensional muqarnas views. The user can have multiple views types open simultaneously so they can see changes in one view displayed immediately in another view. Choose **Muqarnas Types** from the menu bar, to display each type as a separate menu list, see Fig. (5.26).

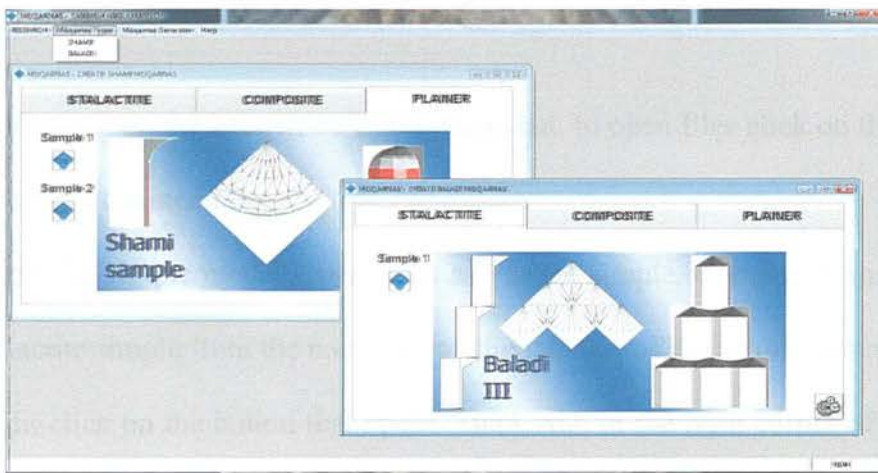


Fig. 5.26. Display Muqarnas Types

Each type has a mine-screen that includes the three model types, Plainer, Composite and Stalactite, in a menu bar. The user can customise this to create any muqarnas model type, linked with the AutoCAD program, which will help the designer in designing muqarnas types. The design of the muqarnas model types is drawn in three dimensions and rotated on the screen so the user can see it from all sides. All this is done in one simple process.

To display open Muqarnas Types view:

1. Click on Muqarnas Types on the menu bar.
2. Select from menu list of Muqarnas Types.



3. Choose type (SHAMI or BALADI).
4. To select any of the model types, click on the menu bar list: Plainer, Composite or Stalactite.
5. Click on the Open AutoCAD button in the right corner of the types from the dialogue box of AutoCAD Generator Sample, to create and develop new types of muqarnas.

To close an open Muqarnas Types view:

1. Right-click on the Muqarnas Types menu list, to open files click on the model type from the menu list.
2. Select the simple model types, such as Plainer simple, Composite simple and Stalactite simple from the menu list on the left side of the sub-mine-screen.
3. Right-click on the button that opens AutoCAD, in the right corner of the sub-mine-screen.
4. Select Close Model Types view, click X in the upper right corner of the sub-mine-screen.

The **Muqarnas Generator** view display is the contents of the AutoCAD generator sample and allows access to each generator (Alphabet Mould or generator sample 1, 2 and 3) in a separate dialogue box. There are single component and group component muqarnas elements, which allow the user to create muqarnas units to represent clear formative creations. The user can have multiple view types open simultaneously so they can see changes in one view instantly displayed in another, as seen in Fig. (5.27).

If the user chooses Alphabet Mould they can create and customise any text element of the muqarnas. If the user chooses Generator Sample they can customise to create any sample of the muqarnas generator, and choose from those samples, and be done in one simple operation, or choose from one sample and then another.

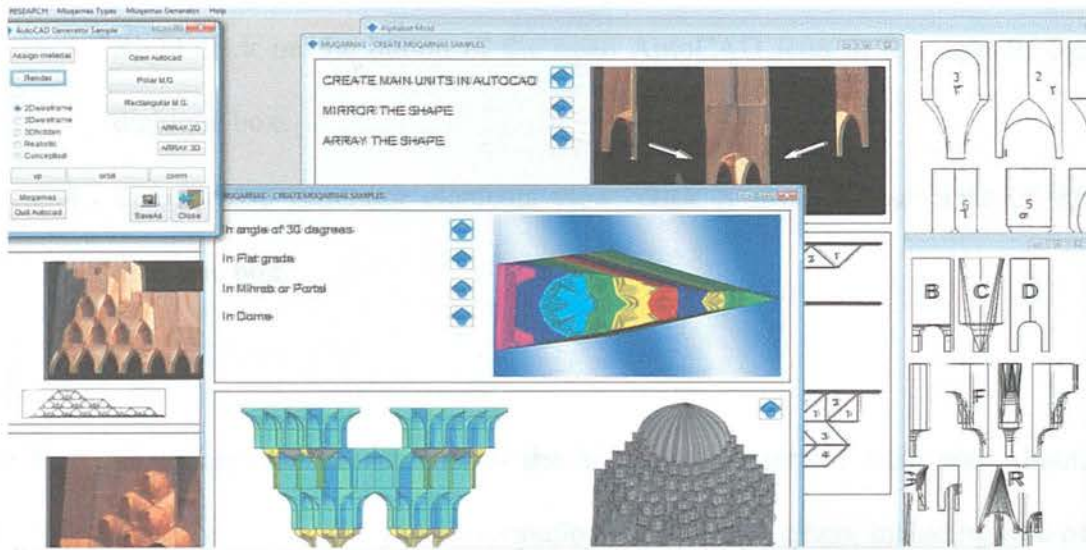


Fig. 5.27. Display Muqarnas Generator

To display open Generator Muqarnas view:

1. Click on the Generator Muqarnas from the menu bar.
2. From the Generator Muqarnas display choose one of the generator elements.
3. To select any generator element, click in a Tool Bar Alphabet or generator sample 1, 2 and 3, or display Muqarnas AutoCAD Control, to control any sample chosen from the menu list.
4. Right-click on the button to open the AutoCAD program and click on the AutoCAD icon in the middle of the generator elements from the dialogue box.

To close an open Generator Muqarnas view:

1. Right-click on the open generator elements view from the menu list.
2. Select the simple generator elements, such as Alphabet simple, Generator sample 1, 2 and 3 in the left of the generator elements from the sub-mine-screen.
3. Right-click on the button of the open AutoCAD icon in the right of the dialogue box.
4. Select close generator elements view; click X in the upper right of the dialogue box.

The **Help** view displays the contents of the Muqarnas Generator Help and About, which provides the user with all the information about the program, including title of the thesis, name of the author, name of the programmer, purpose of the program, type, size, date modified and licence agreement. Help will guide the user to all the icon information of the program, so it is useful for navigating through the design quickly, as seen in. (5.28).



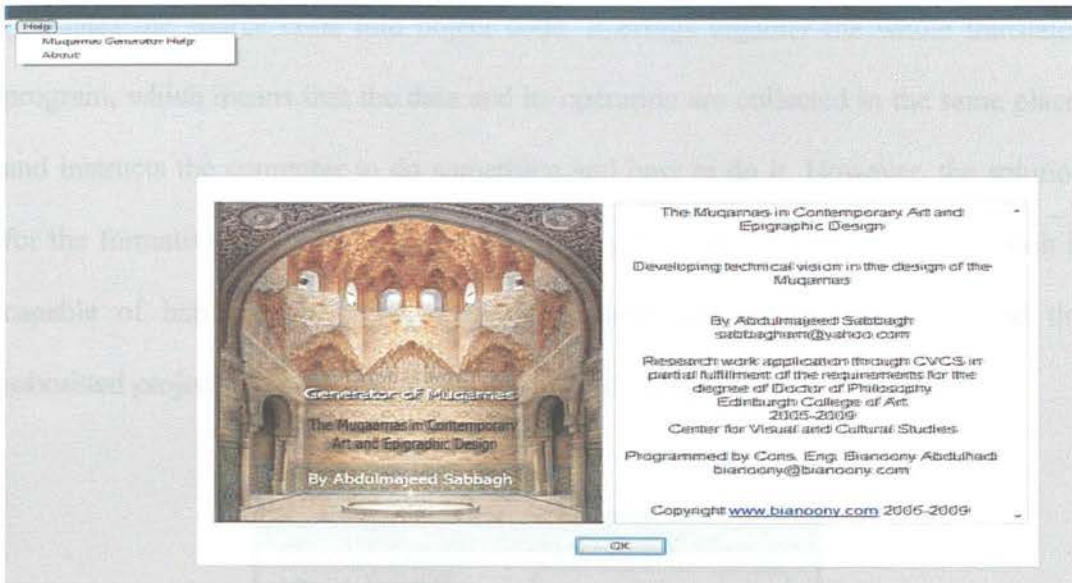


Fig. 5.28. Display Help and About

To display Help open views:

1. Click on the Help from the menu bar.
2. Select Help from the menu bar, choose Muqarnas Generator Help and About.

To close an open Help view:

1. Right-click on the open Help view.
2. Select Close Help or click the X in the upper right corner of the Help from the menu list.

### 5.6.2. Accuracy of the Generator of Muqarnas software by use of AutoCAD

AutoCAD is the application software term for Computer Aided Design (CAD), used by architects, engineers, draughtsman and other professionals to create two- or three-dimension drawings and models (AutoCAD, 2008). The author has used it proficiently to execute on instruction his program Generator of Muqarnas, which

translates the source code into object code. It brings together the whole translated program, which means that the data and its operation are collected in the same place, and instructs the computer to do something and how to do it. However, the solution for the formative generator of the muqarnas program, as a working method which is capable of handling the most complex constructions of the muqarnas and the **submitted project's** model, depends on using CAD (Fig. 5.29).



Fig. 5.29. Open AutoCAD Generator Sample

The author has developed a framework that can run the muqarnas elements in a space with the elaboration maths framework. He translated the formulation of each **element's** muqarnas shape into a programming language, in order to generate these shapes automatically, as well as to move, rotate, or stretch them, using the CAD as a tool, or to apply any AutoCAD command on the generated shape, e.g. Copy, Mirror, Render, and so on.

In the capacity of integrating the text-code function with the program, and to work with the elements already in the program, choose sub-menu bar Muqarnas AutoCAD

Control, from the Muqarnas Generator menu bar. Then from the dialogue box select either Polar M. G. or Rectangular M. G. as in Fig. (5.30).

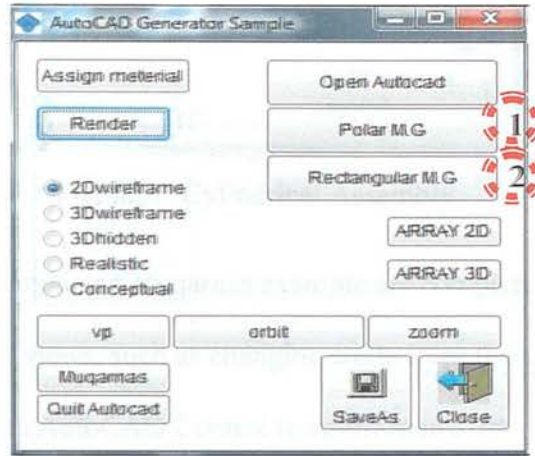


Fig. 5.30. Polar M.G. or Rectangular M.G.

To create muqarnas model Polar M. G. or Rectangular M. G. do the following:

1. Click Muqarnas Generator from the menu bar.
2. Select Muqarnas AutoCAD control from the menu list.
3. Select Polar M. G. or Rectangular M. G. from the dialogue box.
4. The Polar M. G. (Cylindrical Assembly) Setting will appear as Fig. (5.31).
5. Select user choice into text box.
6. Set up the new selection in the text box, as number of rows, units in each row, angle (from 0 to 360 degree) and unit type.
7. Select Create in the left corner of the dialogue box, to see that creation on the AutoCAD, and design any new cylindrical assembly of muqarnas.
8. Select Close in the right corner or click X in the upper right corner of the sub-menu screen.



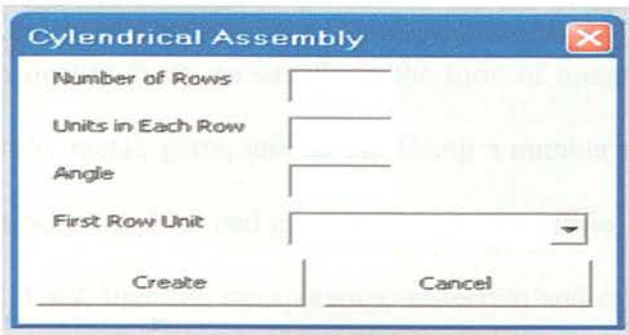


Fig. 5.31. Cylindrical Assembly

After the first steps of creating a muqarnas example are complete, the user can continue to create more views, such as changing angle from the vision point (VP).

1. Select Muqarnas AutoCAD Control from the menu list.
2. Click on VP from the dialogue box, see (Fig. 5.29), and another dialogue box will appear.
3. Select User Set Viewing Angle from the Viewpoint Presets dialogue box (Fig. 5.32).
4. Click on Set to Plan View to see the created muqarnas from several angles.
5. Click OK to set or Cancel, Close or Help.

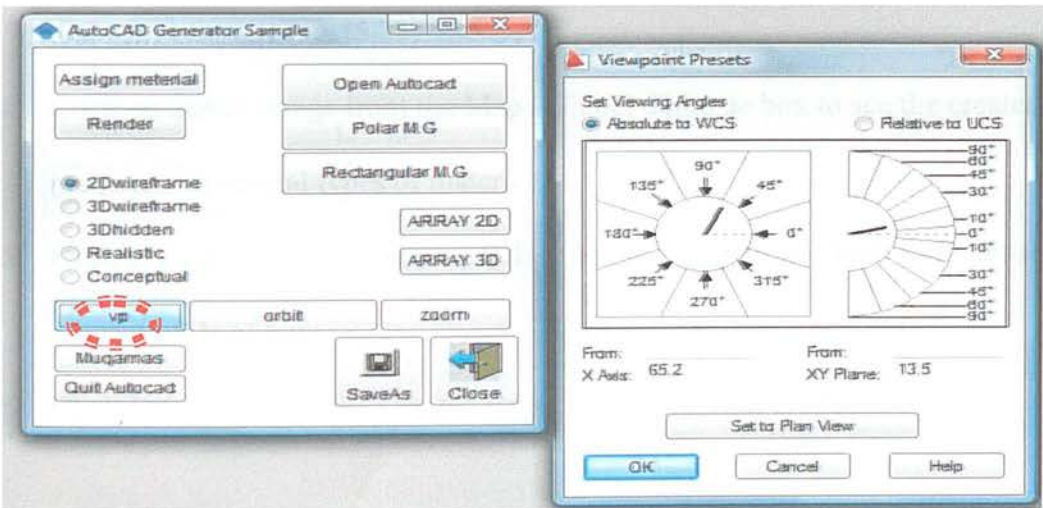


Fig. 5.32. Viewpoint Presets from VP dialog box



Choose Select Image and Material to Objects to see the available materials. In the software program facility these are usually in the form of image files, as pictures of wood, stone, marble, metal, glass, and so on. Using a number of colours that could form visible colours, as red, blue and green, with the possibilities of probability ( $R256 * B256 * G256$ ). Thus, lighting, transparency, reflection and many other features of the computer facility can be controlled.

The author has thus illustrated how AutoCAD tools are used to move through the Generator of Muqarnas program to highlight the muqarnas, providing great efficiency and reliability in the processing of sequences.

#### **Access to the Materials:**

1. Select Muqarnas AutoCAD Control from the menu list.
2. Click on Assign Material from the dialogue box, see Fig. (5.33). The AutoCAD dialogue box will then appear.
3. Select User Selection Material from Available Material in the Drawing dialogue box, see Fig. (5.33).
4. Click on Select Image from the Maps-Global dialogue box to see the created muqarnas in several types of material.
5. Choose Image Material from the Select Image File dialogue box, and choose All from File of type.
6. Click OK Select Image to set the target, or X or Cancel to close.

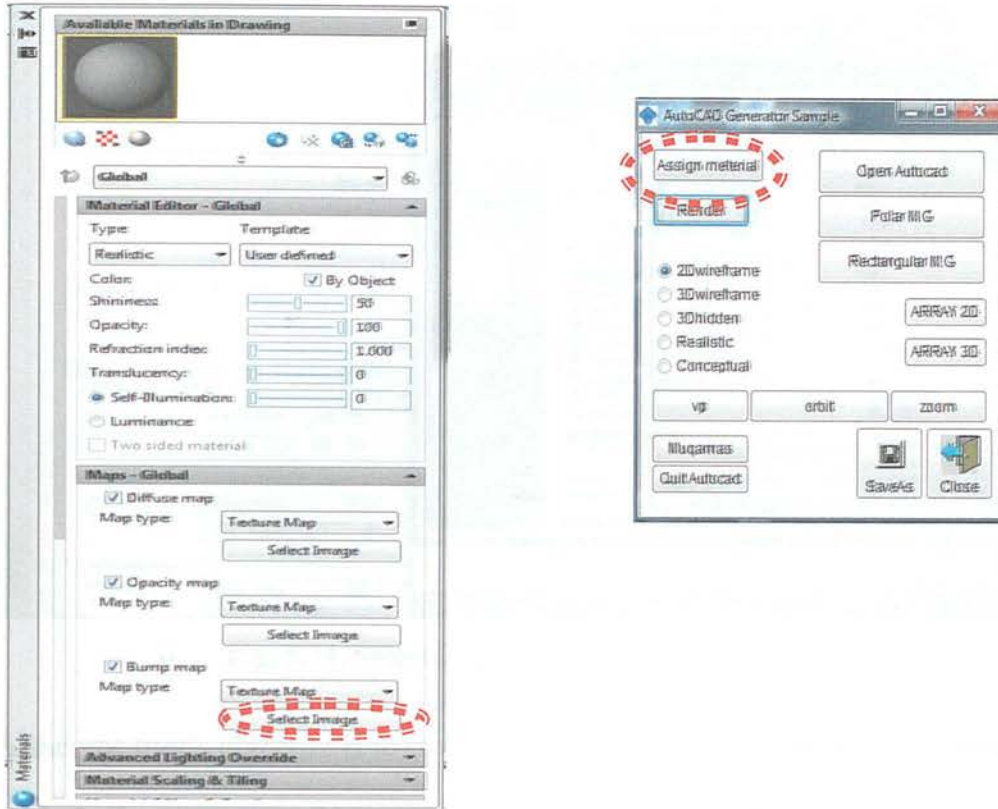


Fig. 5.33. Available Material in Drawing from Assign Material.

### **Editing Materials:**

1. After choosing the image material from the Select Image File dialogue box, and choosing All from File of type. The AutoCAD dialogue box will appear. Select from all material images in the dialogue box selection.
2. Select material image name or any different material name that the user may have attached to use with the muqarnas element. The user can accept these or alter them by clicking on the Select Image from Maps-global dialogue box and making a new selection, see Fig. (5.34).
3. Click on the Material to Objects icon in the upper right dialogue box, to apply the desired material.
4. Click OK Select Image to set the target, or X or Cancel or close.

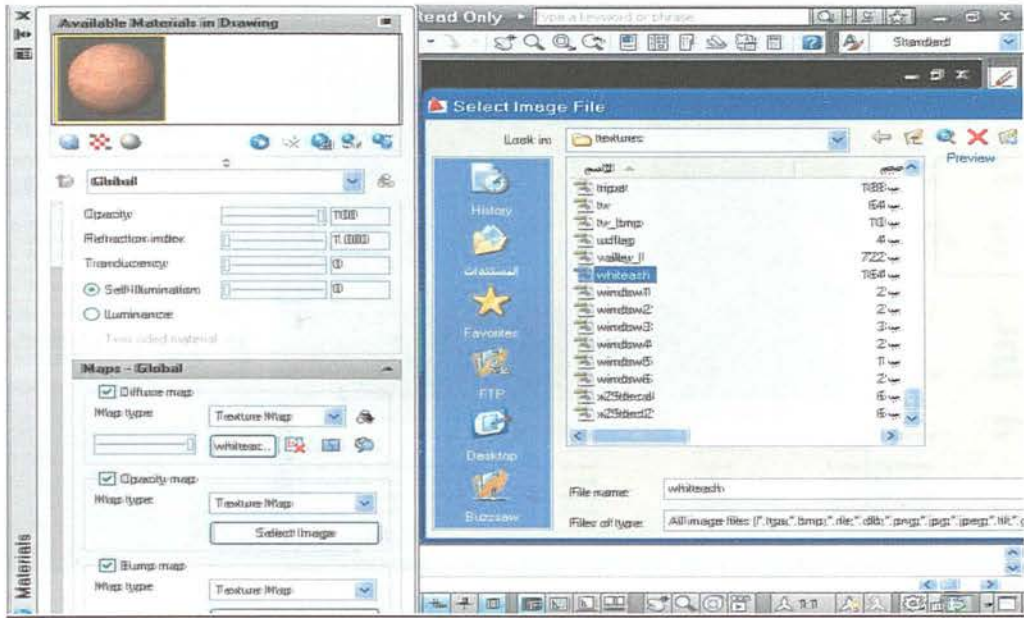


Fig. 5.34. Select Image File and Files of type

Whether the user's objective is to create a new muqarnas object or to use the samples already in the Generator of Muqarnas program, the user needs a selection tool, with technical information by Render option. Using the muqarnas sampling, as render statistics, materials, sampling, shadows, ray tracing, lighting, visual and processing. It can move, rotate, or stretch it by simply manipulating the muqarnas handles.

#### Access to Render:

1. Select Muqarnas AutoCAD control from the menu list.
2. Click on Render from the dialogue box, as Fig. (5.35). The AutoCAD dialogue box will appear.
3. Choose any sample from the Muqarnas Generator dialogue box.
4. Click on Render, to see the sample muqarnas with several options and information, as Fig. (5.35).
5. Click OK Select Image to set the object, or X or Cancel to close



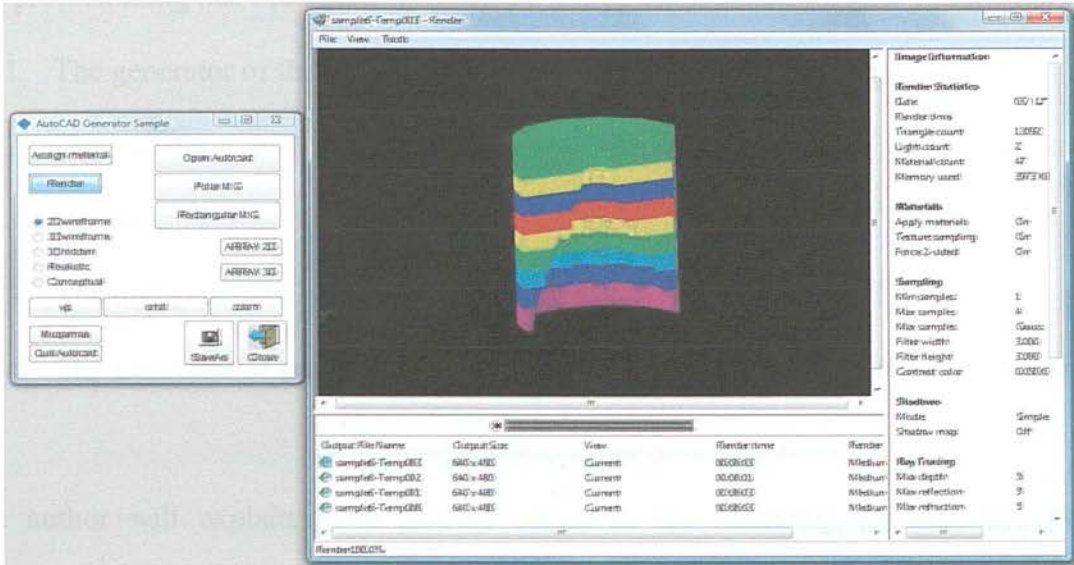


Fig. 5.35. Render

**To move a muqarnas sample:**

1. Click on the sample to select it. It should become highlighted.
2. Move pointer over the mouse handle in the centre of the sample.
3. The Move cursor appears.
4. Click and drag the sample to move it to its new position.

**B. To lengthen or stretch a muqarnas sample:**

1. Click on the sample to select it. It should become highlighted.
2. Move pointer over the mouse handle on the side of the sample.
3. The stretch pointer appears.
4. Click and drag the sample to move it to the desired length.

**C. To modify a muqarnas sample:**

1. Click on the sample to select it. It should become highlighted.
2. Right-click to display the modification view menu of the Render dialogue box.
3. Select the desired modification from the list.

The programming has been done to complete this phase in several stages as follows:

1. The generator of the muqarnas types (SHAMI or BALADI) (Fig. 5.26).
2. The generator of a single component of the muqarnas (AutoCAD Generator sample).
3. The text generator of the muqarnas (Alphabet Mould) (Fig. 5.27).
4. The generator of unrivalled designs of muqarnas (Generator sample 1, 2 & 3).

The author will explain these process stages in the following section, through presenting the Generator of Muqarnas program in terms of ease of use and usability:

### **5.6.3. Usage of the Generator of Muqarnas software**

The Generator of Muqarnas software reflects the idea of the results of the study, which is driven to provide a new version of modern muqarnas. The author has divided the usability of the Generator of Muqarnas software into two parts: generating muqarnas from muqarnas types and generating muqarnas from the units of the muqarnas elements, as follows:

#### **5.6.3.1. The Generator of Muqarnas from types of muqarnas**

The types of the muqarnas are represented in the master catalogue of the program, and in the list of pre-made muqarnas. The author used a basic common shape of muqarnas; compare the early squinch-muqarnas with different elaborations, because it is a very basic powerful elaboration shape for creating muqarnas. There are three types of curve-design (SHAMI) and three types of keel-arch design (BALADI). This could go by one category to another, which will follow from one category example to another. These types are divided into three sub-types (Plainer, Composite and

Stalactite). All the sub-type resources from various multi-types and styles relevant to the whole study, as the author mentioned in Chapter Two of this thesis, are represented in the list of the muqarnas types.

To create Muqarnas Types: SHAMI or BALADI, do the following:

1. Choose **Muqarnas Types** from the menu bar and select SHAMI or BALADI.
2. Select **SHAMI** from the menu list.
3. Choose the model type such as Plainer, Composite or Stalactite from the sub-menu list, select sample 1 or 2, in the left from the sub-mine-screen (Fig. 5.36).
4. Click on the button of the open AutoCAD icon in the right corner of sub-mine-screen, to create and design any new SHAMI types of muqarnas.
5. To close SHAMI type, click X in the upper right corner of the sub-mine-screen.

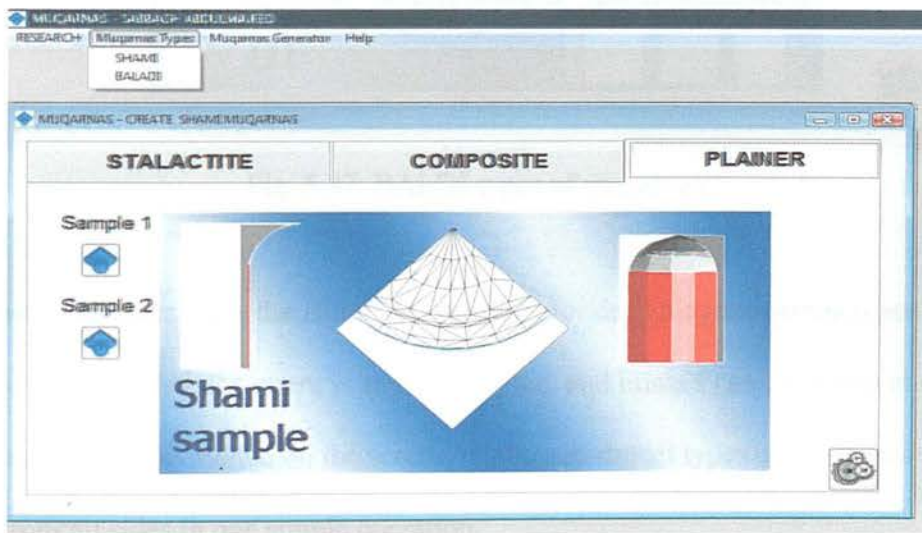


Fig. 5.36. SHAMI types of muqarnas.



**To create Muqarnas BALADI types as well, do the following:**

1. Choose **Muqarnas Types** from the menu bar and select SHAMI or BALADI.
2. Select **BALADI** from menu list.
3. Choose the model type such as Plainer, Composite or Stalactite from the sub-menu list, sample 1 or 2, in the left from the sub-mine-screen (Fig. 5.37).
4. Click on the AutoCAD button icon in the right corner of sub-mine-screen, to create and design any new BALADI types of muqarnas.
5. To close BALADI type, click X in the upper right corner of sub-mine-screen.

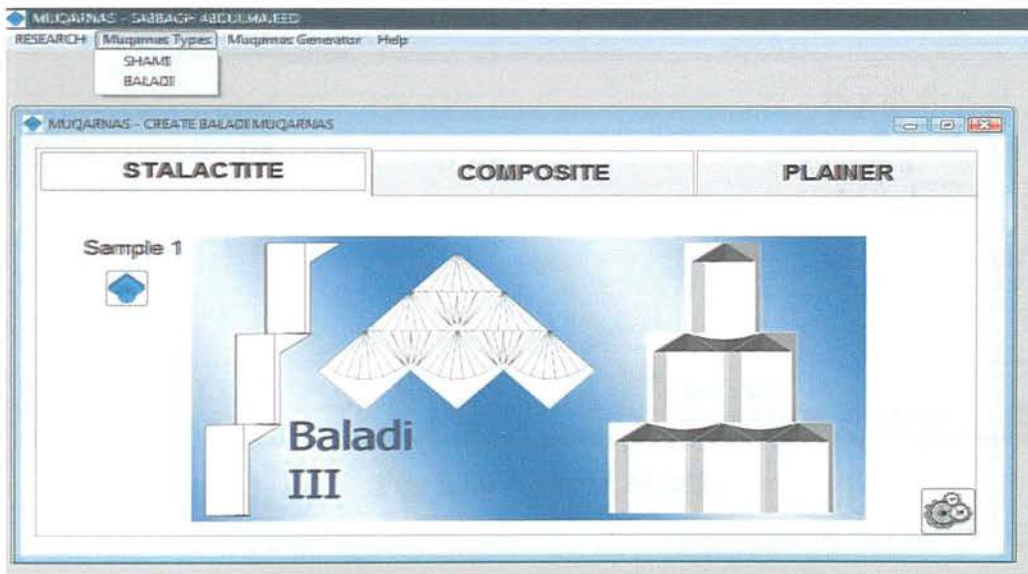


Fig. 5.37. BALDI types of muqarnas.

Whenever the user starts the AutoCAD program for designing muqarnas types it can open a new, untitled document in the work space, and images can be drawn in three dimensions and the rotated on the screen, so the sub-model types of muqarnas can be seen from all sides in one simple operation.



5.6.3.2. The Generator of Muqarnas from text Alphabet Mold

The Muqarnas Generator software generates muqarnas text and processing designs of Alphabet Mold, which are on rows, columns and circles (inner and outer circle or perimeter). There are single component element and group component elements of muqarnas, which allows the user to create muqarnas units to represent clear formative creations. To work with muqarnas units that are already in the program, choose from the Muqarnas Generator **menu bar**, and choose **Alphabet Mold I** from the menu list. Another dialogue box will appear in the sub-screen, as Fig. (5.38).

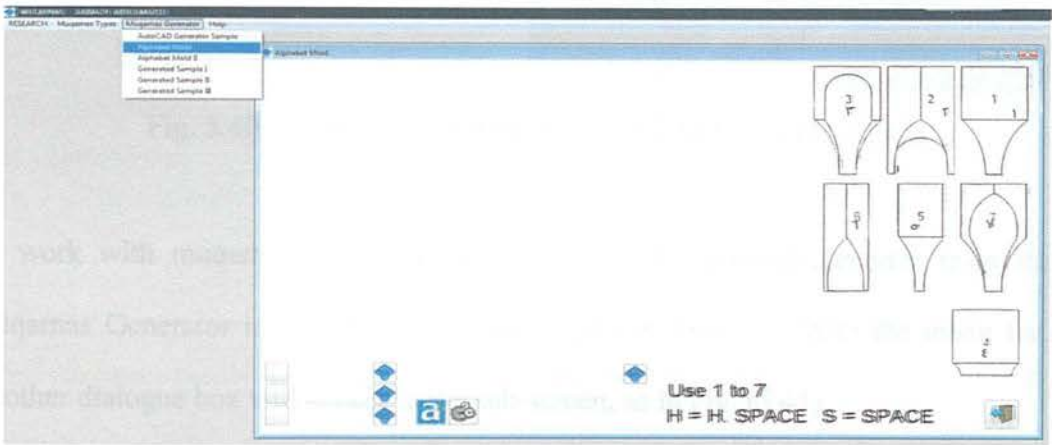


Fig. 5.38. Alphabet Mold I

The names of Alphabet Mold **I** **unite** are in Fig. (5.39):

1- Dembbouq	2- Serwaliya, or bouja (pants)	3- Ktaf square base	4- Mesdouda (closed motif)	5- Loza (almond)	6- Moftuha (open motif)	7- Ktaf triangle base

Fig. 5.39. Alphabet Mold I units

The user chooses more than one unit they can be assembled in one, two or three rows singly or together, in the dialogue **box of the Alphabets of Mold I**. For example, in Fig. (5.40) the three units (e.g. 3 + 7 *Katf* triangle and square base, 1 *Dambbuq*, 2 *Serwaliya* or *Bojja*, and 4 *loza*) are assembled in the **Alphabets of Mold I**.

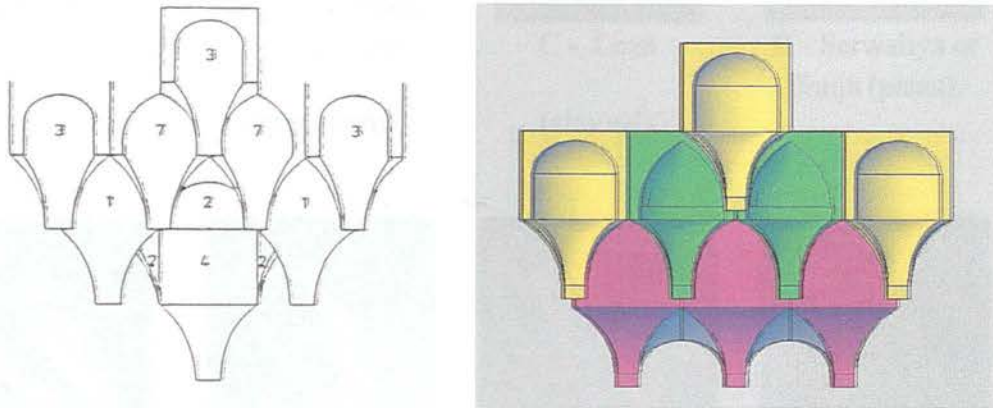


Fig. 5.40. Assembling of Alphabets of Mold I (3, 3773, 1212)

To work with muqarnas units that are already in the program, choose from the Muqarnas Generator menu bar, and choose Alphabet Mould II from the menu list. Another dialogue box will appear in the sub-screen, as in Fig. (5.41).

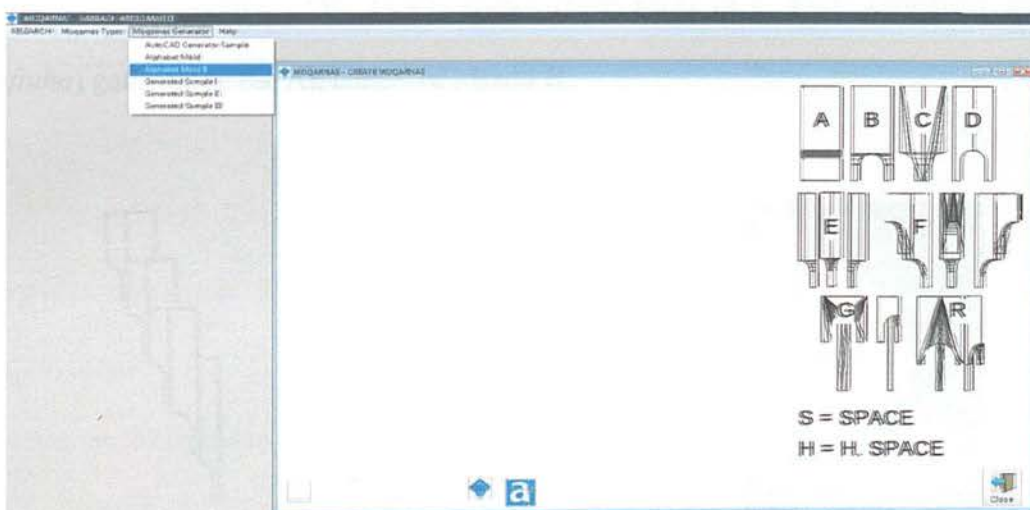


Fig. 5.41. Alphabet Mold II

The name of Alphabet Mold II are in Fig. (5.42):

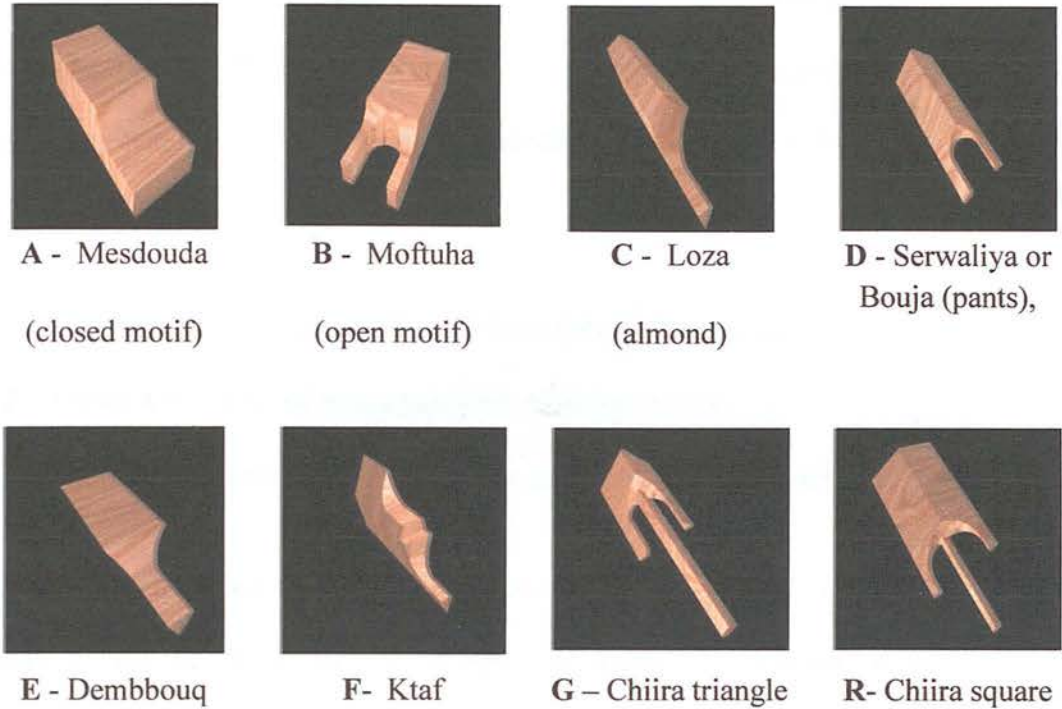
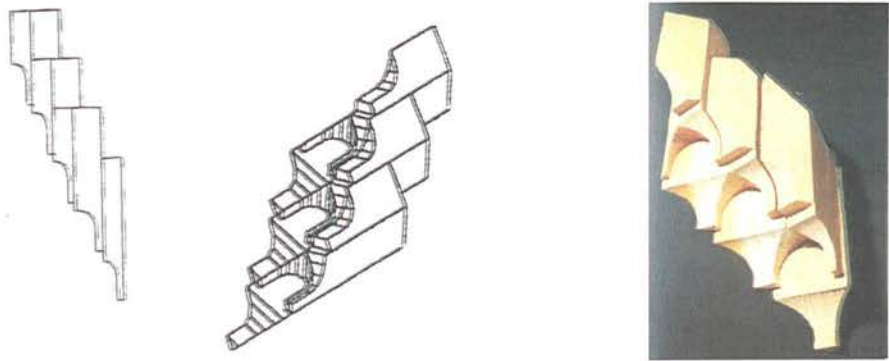


Fig. 5.42. The nemes of Alphabet Mold II

When the user chooses more than one unit to assemble in one, two or three rows, they can fit the numbers of these units singly or together, in the dialogue box of Alphabet Mould II, For example, Fig. (5.43) shows three units (e.g. *Katf*, *Dambbuq* and *Moftuha*) gathered in the **Alphabets of Mould II**.





### 5.7. Implementation of the Generator of Muqarnas software

This phase in the present Generator of Muqarnas software includes those activities required to transition the system from the acceptance stage into creation status. When transferring data from manual records to an automated system, a three-step process is used in the application generator design:

1. Generator of a single component from types of muqarnas.
2. Generator of text of muqarnas from Alphabet Mould.
3. Generator of unrivalled design of muqarnas (Generator sample 1, 2 and 3).

Each element for each direction allows the user to work with muqarnas elements already in the program, switch between its available elements, represent clear formative creations, and also to create additional elements to a particular angle and size, or portion of a drawing, or to move, rotate, or stretch it by simply manipulating the elements of the AutoCAD commands. In the following section, the author will document the project experience and lessons learned for this phase, which is to implement the Generator of Muqarnas software application, including the activities needed for installation, data conversion, and parallel operation as necessary.

#### 5.7.1. Apply Generator of Muqarnas from types of muqarnas

The types of muqarnas design use a basic common shape, because it is a very basic powerful shape. SHAMI and BALADI have three types of convex and concave curves design. This could go by one category to another, which will follow from one category example to another. Each of these is divided into three sub-types such as Plainer, Composite and Stalactite (Fig.2.44).

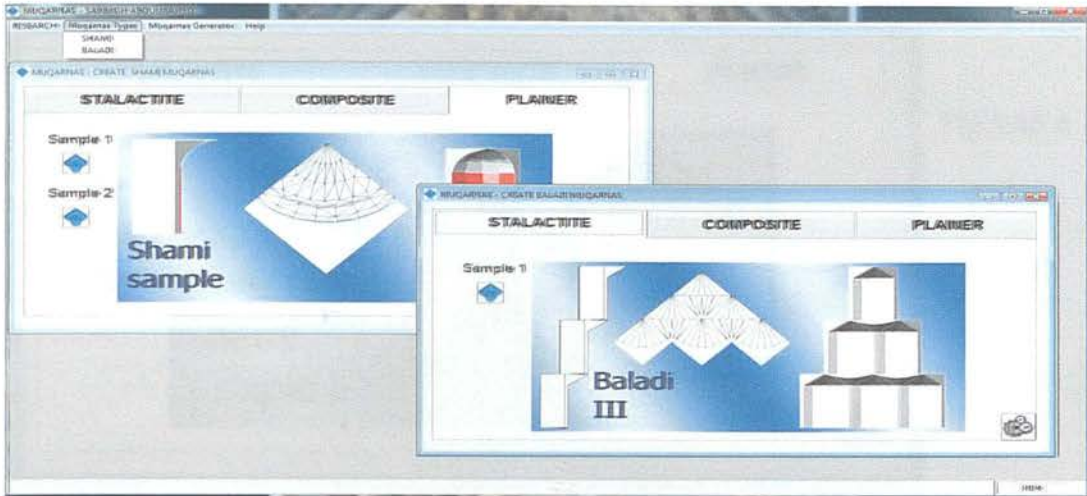


Fig.2.44. Apply Generator Muqarnas from types of muqarnas

To create Muqarnas Types: SHAMI or BALADI, do the following:

1. Choose Muqarnas Types from the menu bar, select SHAMI or BALADI.
2. Select SHAMI from the menu list.
3. Choose a model type such as Plainer or Composite or Stalactite from the sub-menu list, select sample 1 or 2, in the left of the sub-mine-screen (Fig. 5.45, A,B,C).
4. Click on the button of the open AutoCAD icon in the right corner of the sub-mine-screen, to create and design any new SHAMI types of muqarnas.
5. To close SHAMI type, click X in the upper right corner of the sub-mine-screen.

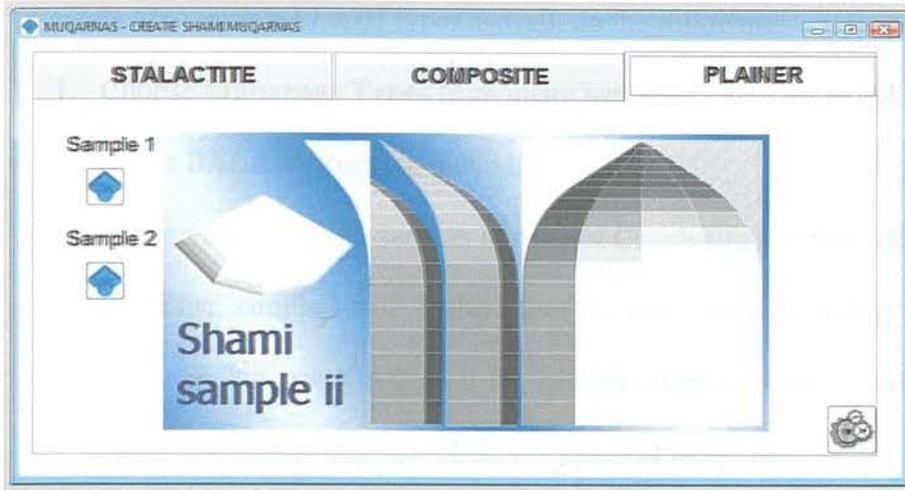


Fig.5.45 A.

Plainer

SHAMI



Fig.5.45 B.

Composite

SHAMI



Fig.5.45 C.

Stalactite

SHAMI



To create Muqarnas **BALADI** types as well, do the following:

1. Choose **Muqarnas Types** from menu bar, select SHAMI or BALADI.
2. Select **BALADI** from the menu list.
3. Choose a model type such as Plainer or Composite or Stalactite from the sub-menu list, sample 1 or 2, in the left of the sub-mine-screen (Fig. 5.46, A,B,C).
4. Click on the AutoCAD icon in the right corner of the sub-mine-screen, to create and design any new BALADI types of muqarnas.

To close BALADI type, click X in the upper right corner of the sub-mine-screen.

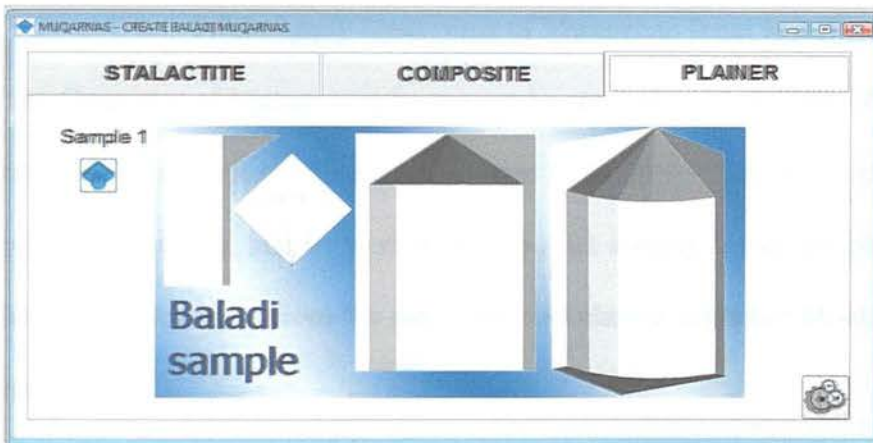


Fig.5.46 A.

Plainer

BALADI

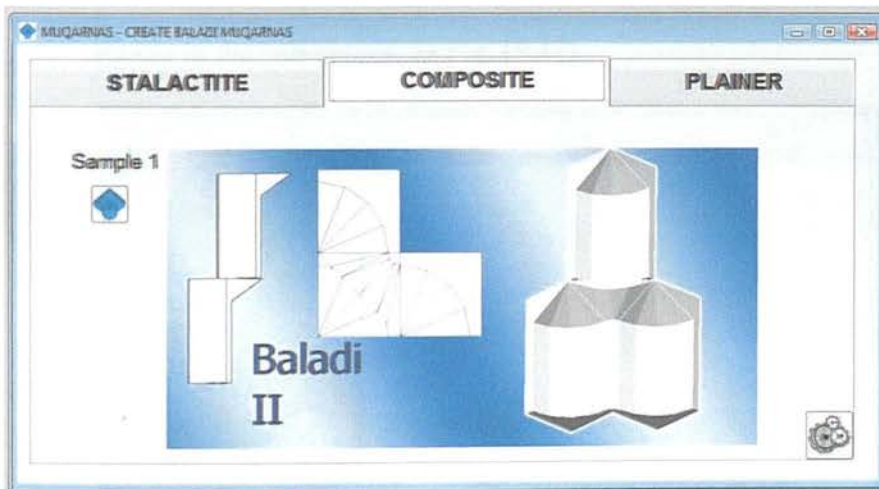


Fig.5.46 B.

Composite

BALADI



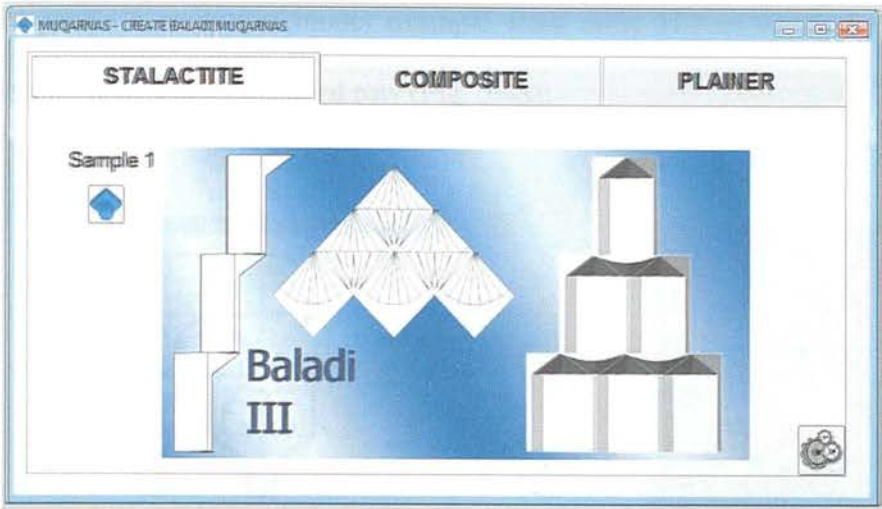


Fig.5.46 C.  
Stalactite  
BALADI

5.7.2. Apply Generator of Muqarnas from text Alphabet Mould.

The Generator of Muqarnas software can be applied to the designs of Alphabet Mould text to represent clear formative creations. In the integration of the text-code function with the program, and to work with elements already in the program, choose from Muqarnas Generator from the menu bar, and choose Alphabet Mould I or II from the menu list.

- A. To create a muqarnas from **Alphabet Mould I**, another dialogue box will appear in the sub-screen, as Fig. (5.47).

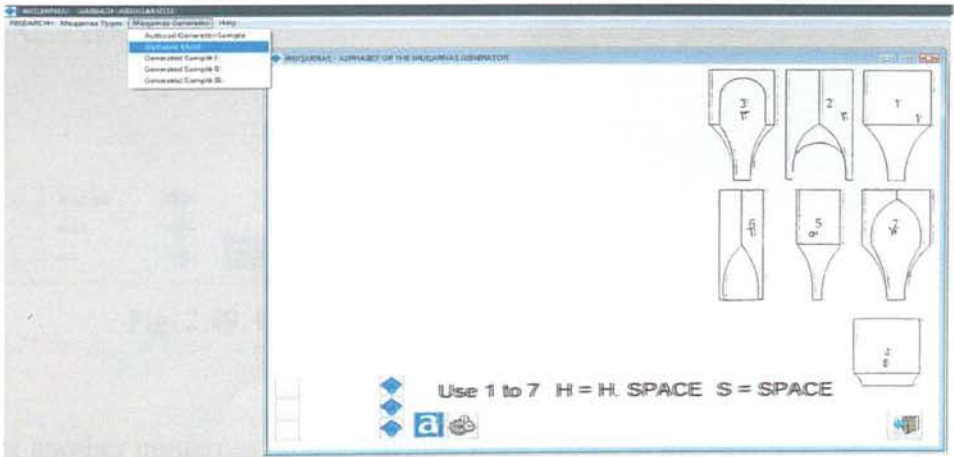


Fig. 5.47. Mine-Screen of Alphabet Mould I

To create a muqarnas model example from units 121 in the first row, 212 in the second row, 121 in the third row (Fig. 5.48):

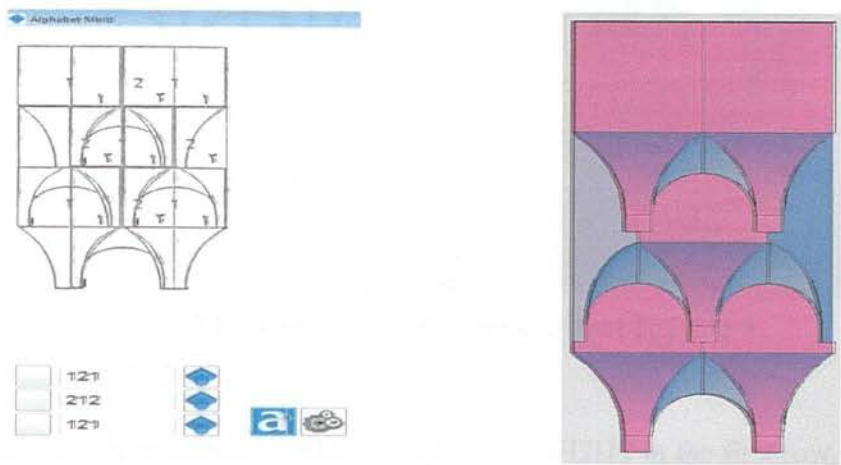


Fig. 2.48. Create muqarnas model from 1 and 2

To create another muqarnas model example from 41212 in the first row, 421 in the second row, 41 in the third row (Fig. 2.49)

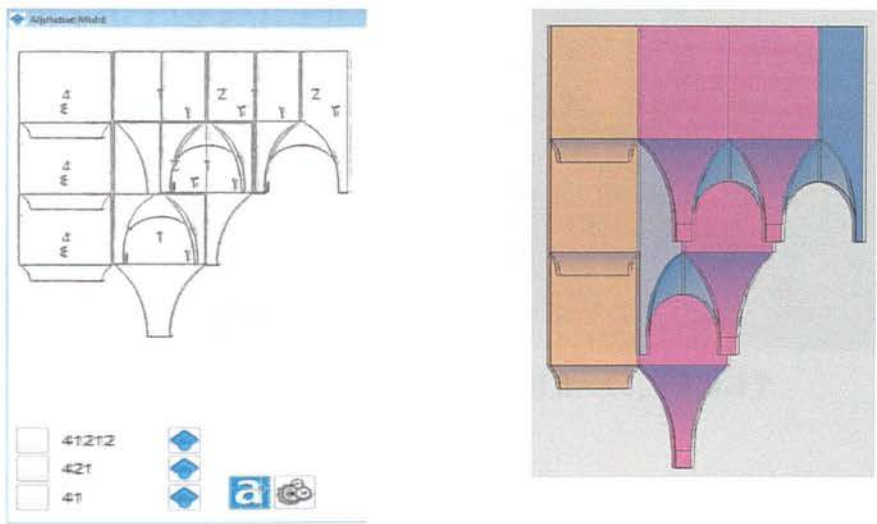


Fig. 2.49. Create muqarnas model from 1, 2 and 4

To create another muqarnas model example from 12312 in the first row, H212 in the second row, SH1 in the third row (Fig. 5.50):

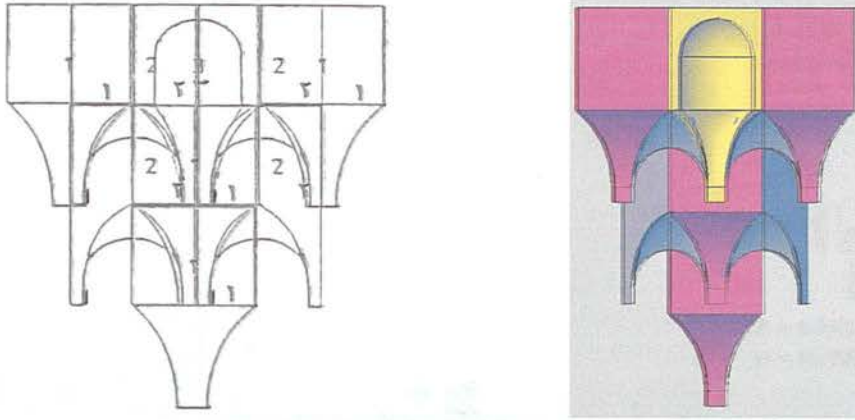


Fig. 2.50. Create muqarnas model from 1, 2 and 3

To create another muqarnas model example from SH7HS in the first row, 3773 in the second row, H1212 in the third row (Fig. 5.51):

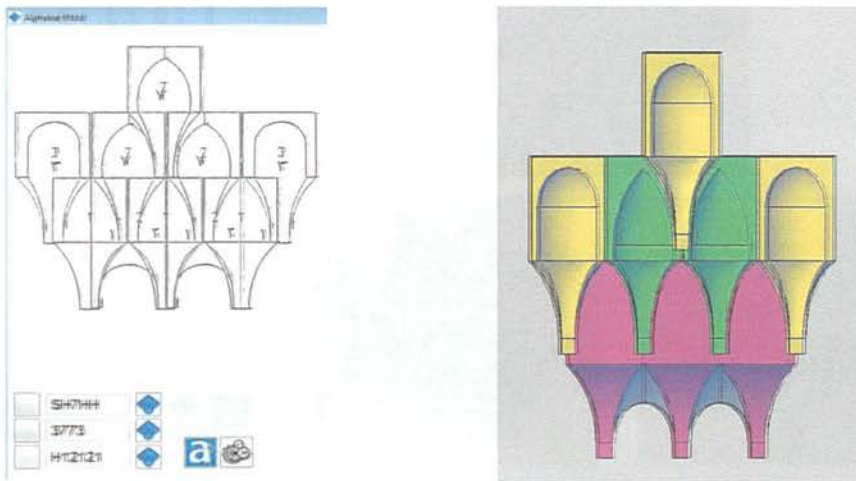


Fig. 2.51. Create muqarnas model from 1, 2,3 and 7

B. To create a muqarnas from Alphabet Mould II, another dialogue box will appear in the sub-screen, as Fig. (5.52).

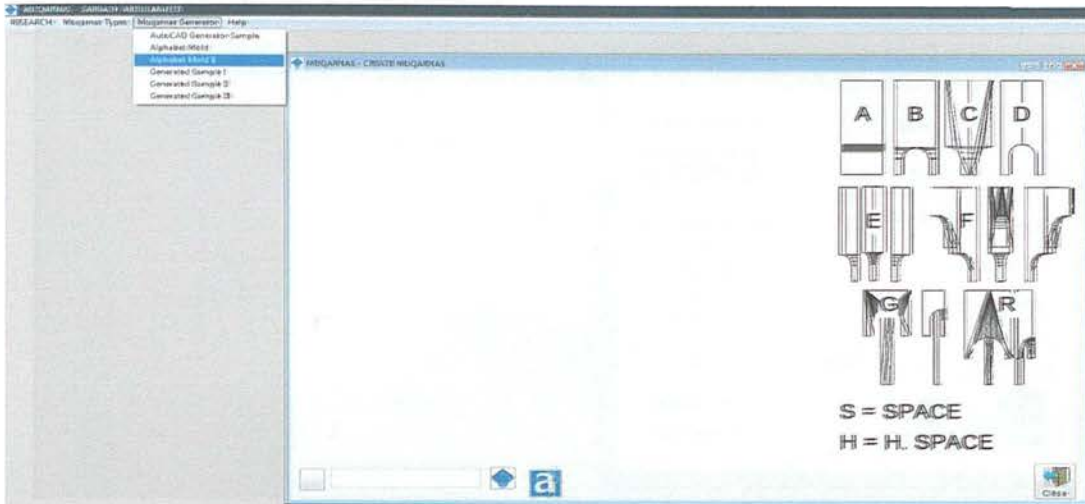


Fig. 5.52. Mine-Screen of Alphabet Mould II

To create a muqarnas model example from units f, f, f, f, f. (Fig. 2.53)

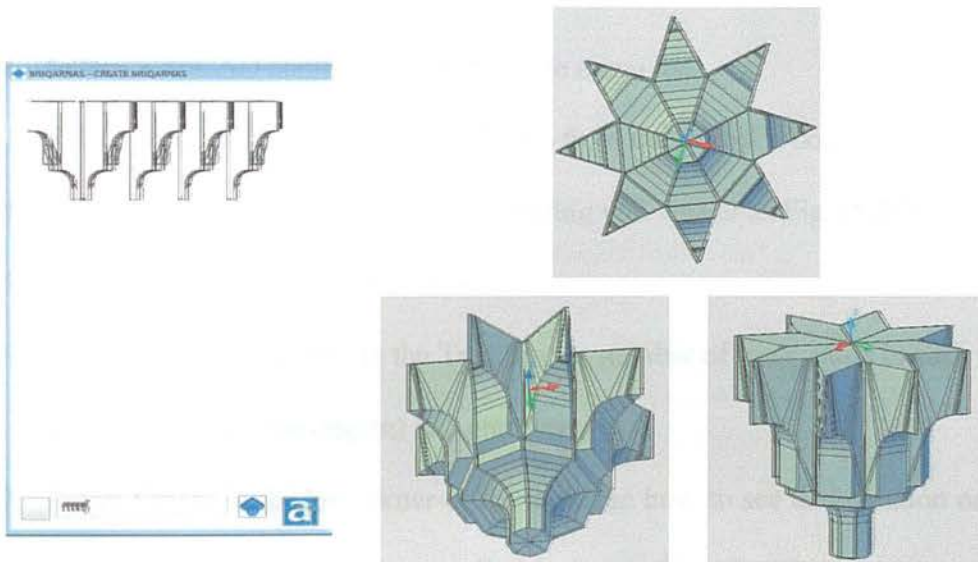


Fig. 2.53. Create muqarnas model from f, f, f, f, f.

To create muqarnas model Polar Muqarnas Generator (M. G.) or Rectangular (M. G.):  
Choose Muqarnas Generator from the menu bar, and from the menu list choose AutoCAD control sample. Then from the dialogue box select from either Polar M. G. or Rectangular M. G. as Fig. (5.54).



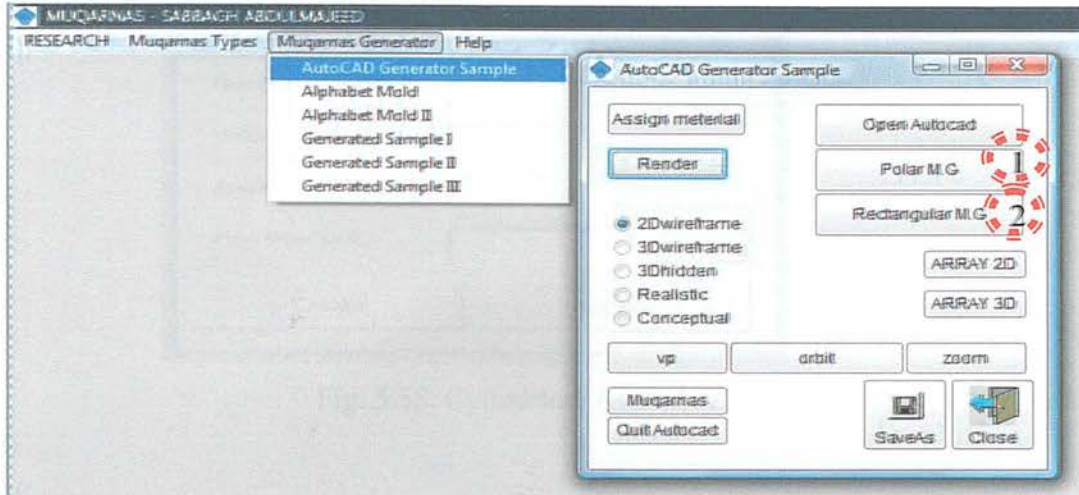


Fig. 5.54. Polar M.G or Rectangular M.G

To create muqarnas model Polar M. G. or Rectangular M. G. do the following:

1. Click Muqarnas Generator from the menu bar.
2. Select AutoCAD control sample from the menu list.
3. Select Polar M. G. or Rectangular M. G. from the dialogue box.
4. Polar M. G. (Cylindrical Assembly) Setting will appear as Fig. (5.55).
5. Select user choice in the Text box.
6. Set up the new selection in the Text box, as number of rows, units in each row, angle (from 0 to 360 degree) and unit type.
7. Select Create in the left corner of the dialogue box, to see that creation on the AutoCAD, and design any new cylindrical assembly of muqarnas.
8. Select close in the right corner or click X in the upper right corner of the dialogue box.

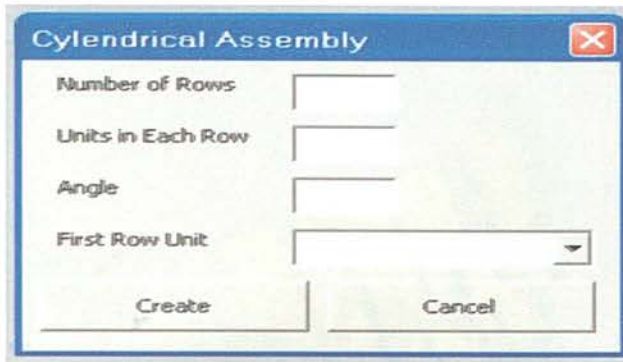


Fig. 5.55. Cylindrical Assembly

The following example is a model of Polar M. G, when they fill up all the Text-box by user, such as 3 Rows, 7 Units in each row, 180 degree and *Chiira* unit name, as Fig. (5.56).

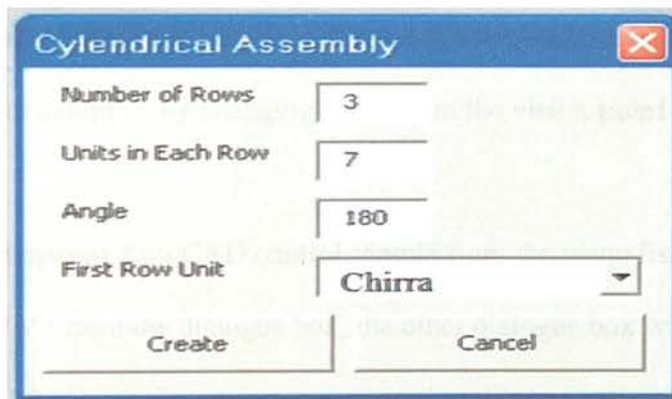


Fig. 5.56. Cylindrical Assemble example

Then click on the Create button in the left corner of the dialogue box. The muqarnas generator program will start to run the tasks to design these units and determine the angles. After a few seconds of formatting all these commands it will be ready for using in the next steps of muqarnas creation, as in Fig. (5.57).

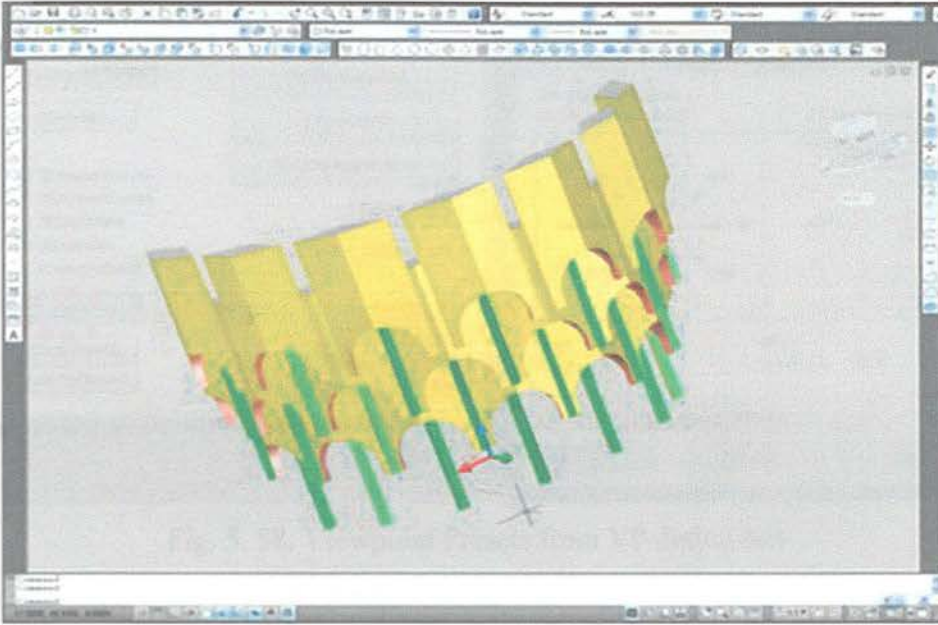


Fig. 5.57. Example of creation muqarnas from cylindrical assemble.

After the first steps of muqarnas creation have been completed, the user can continue to create more, for example, by changing angle from the **vision point (VP)**.

1. Select Muqarnas AutoCAD control sample from the menu list.
2. Click on VP from the dialogue box, the other dialogue box will appear (Fig. 5.58).
3. Select User Set Viewing Angle from Viewpoint Presets dialogue box (Fig. 5.58).
4. Click on Set to Plan View to see the creation muqarnas from several angles.
5. Click OK to set, or Cancel to Close or Help.



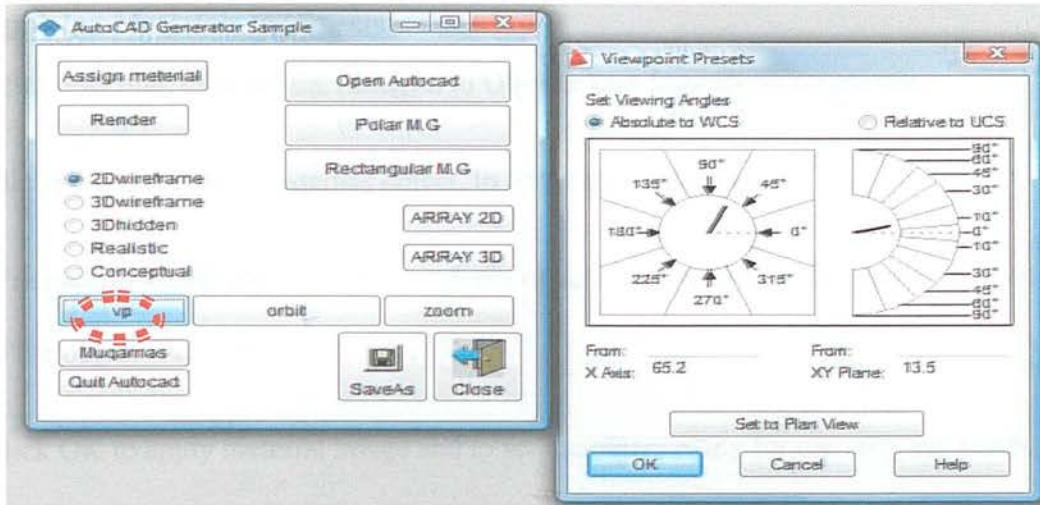


Fig. 5. 58. Viewpoint Presets from VP dialog box

After setting viewing angles, the result of the muqarnas creation example will be as (Fig. 5.59).

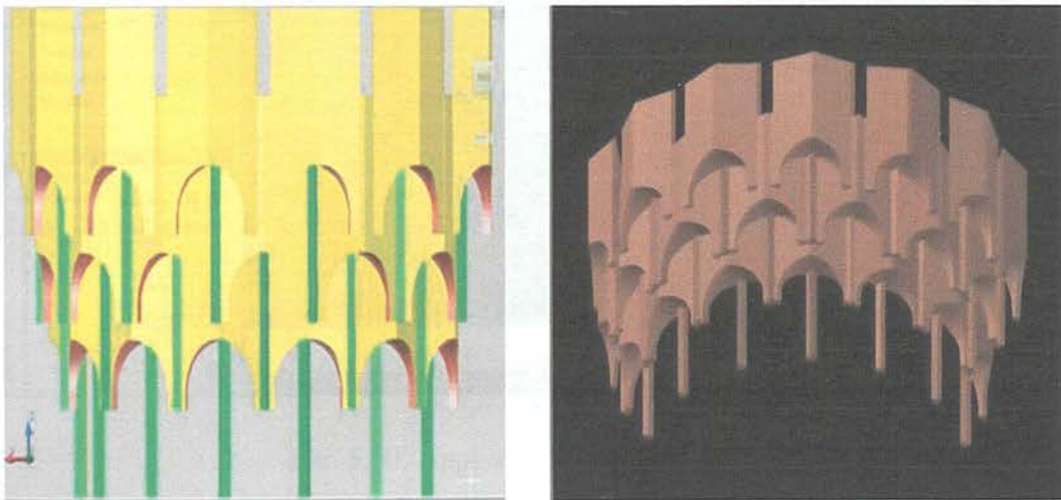


Fig. 5.59. The view after set angles and using Realistic and Conceptual

### Applying Materials to Objects:

After selecting, click on the Material to Objects icon from the dialogue box.

Click on the creation muqarnas object, to apply material image.

Write all in Select Objects in the small dialogue box appearing in the screen in front of the object (Fig. 5.60).

Click OK to apply material image and to set the object ready for carrying out another composition, or X or Cancel to close.

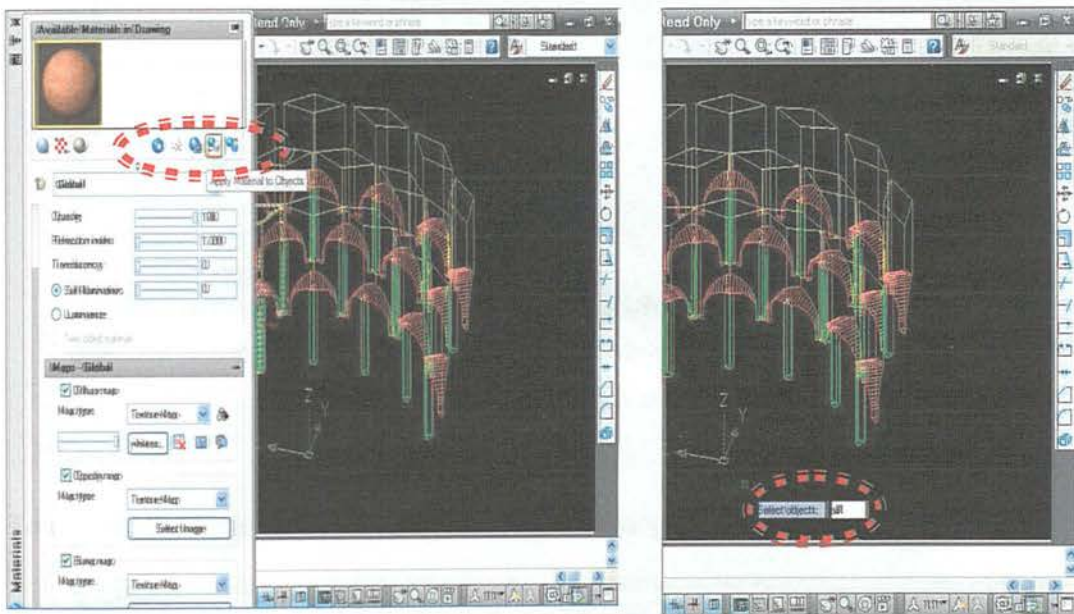


Fig. 5.60. Applying Material to Objects

**Note:** The user can easily create new materials to take advantage of the many more options available or to get just the right combination of components. Any new materials created by the user can be added to an existing group or the user can make a new group.

**Applying Materials to other Objects:**

After designing the muqarnas block, choose material from the dialogue box of the Generator of Muqarnas program or write in the command line: **materials** from AutoCAD. Another performance materials view of Alphabet Mould example (Fig. 5.61):

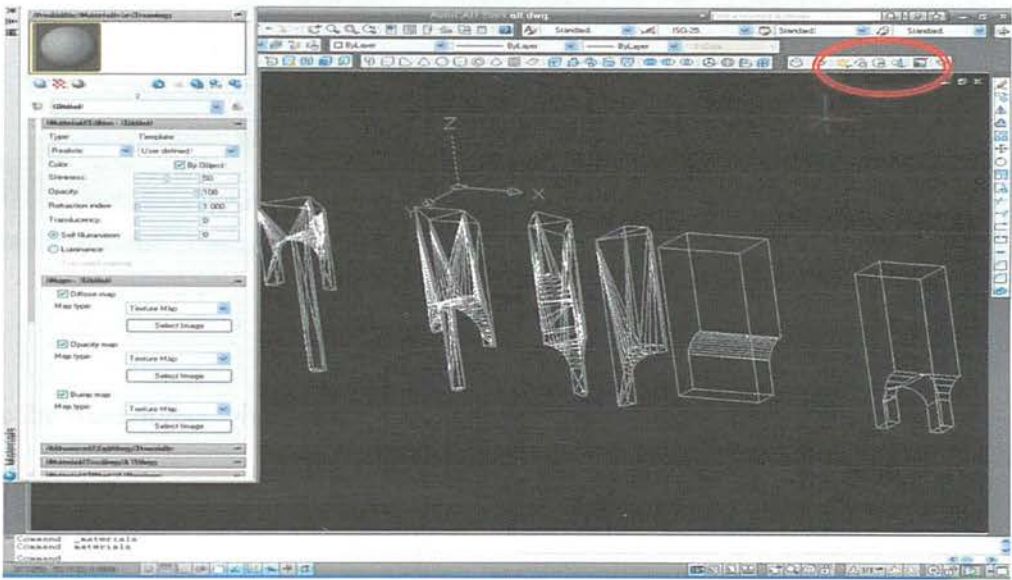


Fig. 5.61. Materials performance

To control the material object from AutoCAD dialog boxes (Fig. 5.62):

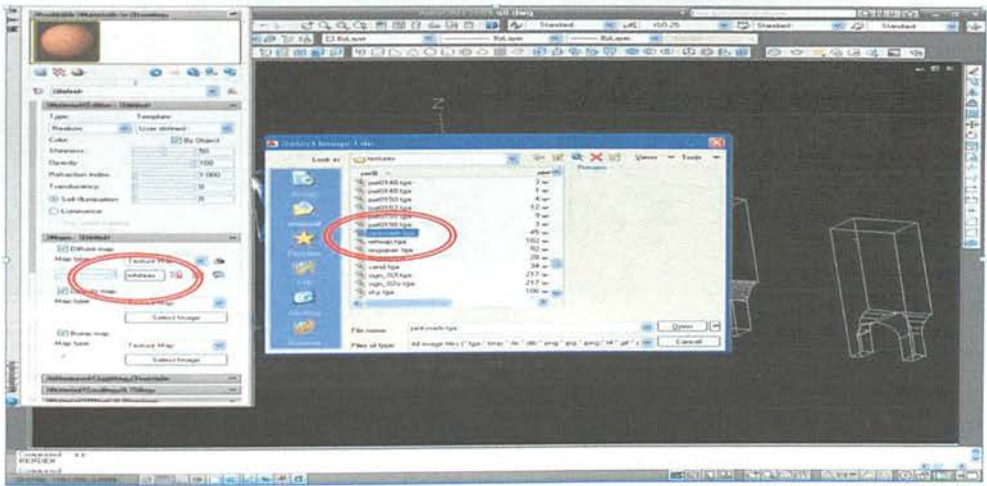


Fig. 5.62. control the material object from AutoCAD dialog boxes



To Apply Material to object (Fig. 5.63):

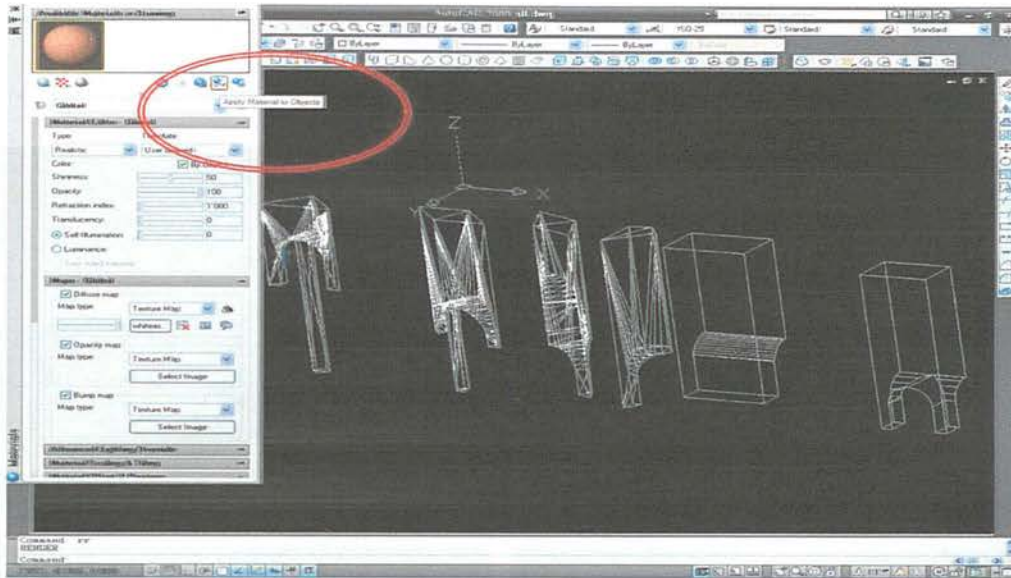


Fig. 5.63. Apply Material to object

To see the final object with material in Rendering view with all object information (Fig. 5.64):



Fig. 5.64. Rendering and object information

To see the objects with different materials and colours in Rendering view with all object information (Fig. 5.65):

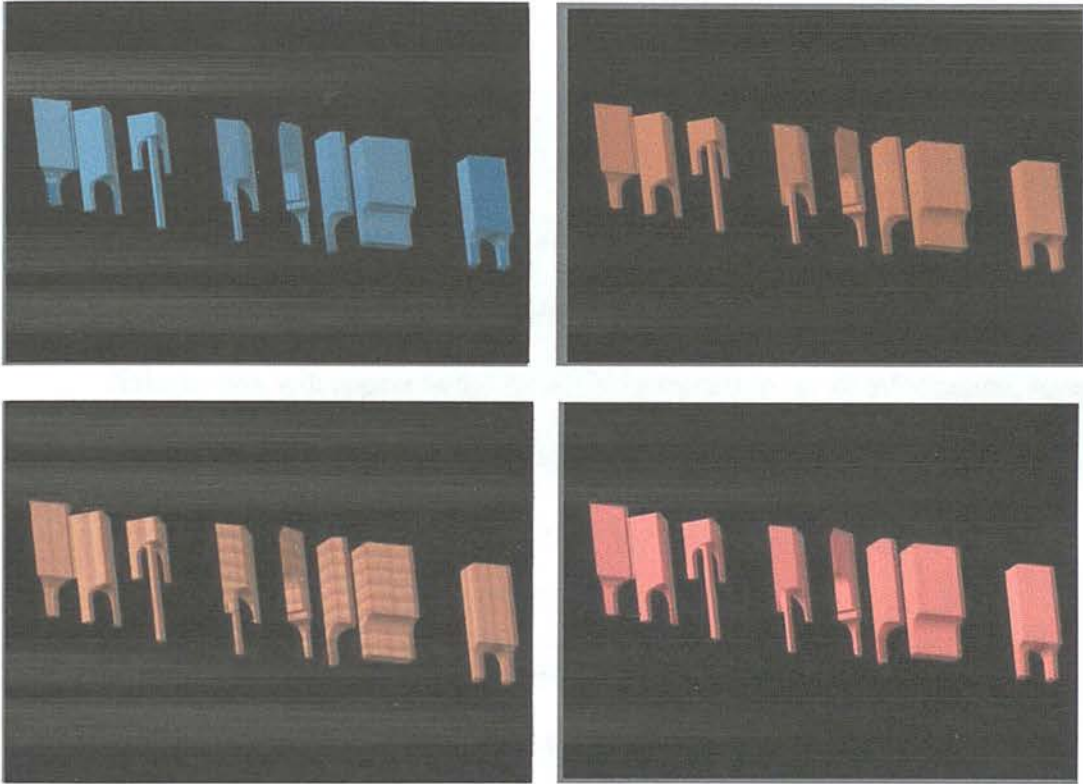


Fig. 5.65. Deferent Rendering and object information

### 5.7.3. Organising the muqarnas views

The Generator of Muqarnas program provides the user with viewers for navigating from one place to another in a muqarnas design project. To work in both two- and three-dimensional views, the user can have multiple views open simultaneously so they can see changes in one view instantly displayed in another.

The Generator of Muqarnas program provides tools with which the user can create the epigraphic muqarnas objects directly on screen. These tools include a feature for activating these elements, such as special functions and special effects – ARRAY 2D,

ARRAY 3D and dissolve design. The author believes that design is thinking, choosing, making and doing. It is shaping, smoothing, reworking, polishing, testing and editing. Using this program offers a mechanism for creating muqarnas objects that allows the user to move his or her ideas and concepts one step closer to reality.

### Access to Array 2D and 3D:

1. Select Muqarnas AutoCAD control from the sub-menu bar.
2. Click on **ARRAY 2D** from the dialogue box, as Fig. (5.29). Another Array dialogue box will appear in the AutoCAD program to set all information, such as row offset, column offset and angle of array.
3. Fill in a number for row offset and column offset, in the dialogue box, as Fig. (5.66).
4. Choose Select Object Icon in the upper right of the dialogue box.
5. Click Preview or OK Select Image to see the object, or X or Cancel to close.

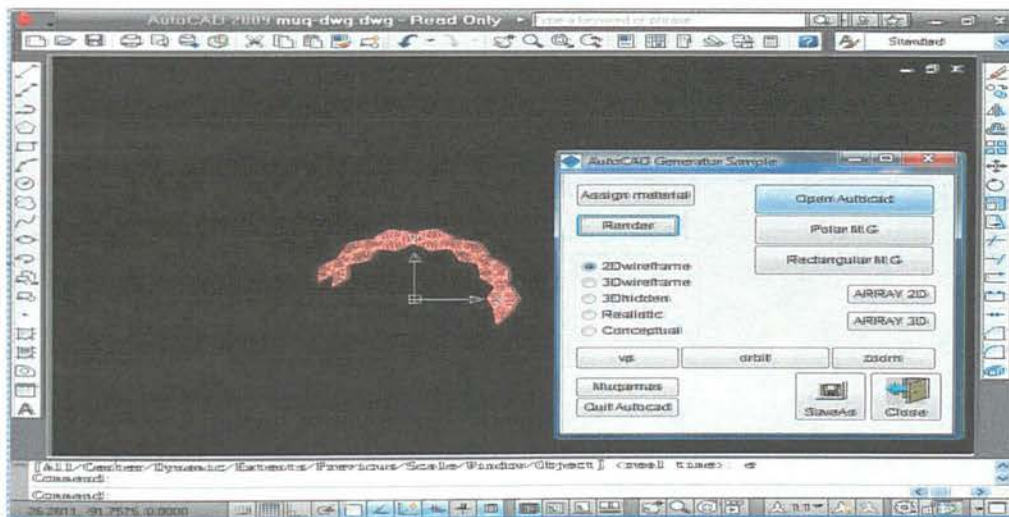


Fig. 5.66. ARRAY dialog box



After select the Array dialogue box will appear in the AutoCAD program to set all information, such as row offset, column offset and angle of array. Then, fill in a number of row offset and column offset, in the dialogue box, as Fig. (5.67).

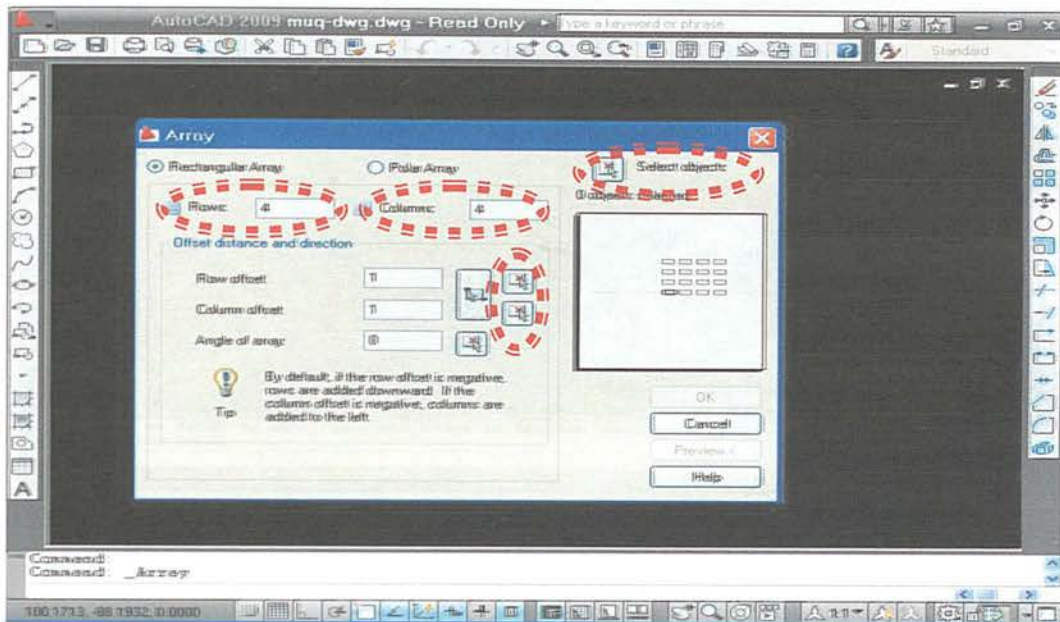


Fig. 5.67. ARRAY dialog box in Auto CAD

After choose **Select object** icon that on the upper right of dialogue box. Then click OK to select image and to see the object, as Fig. (5.68).

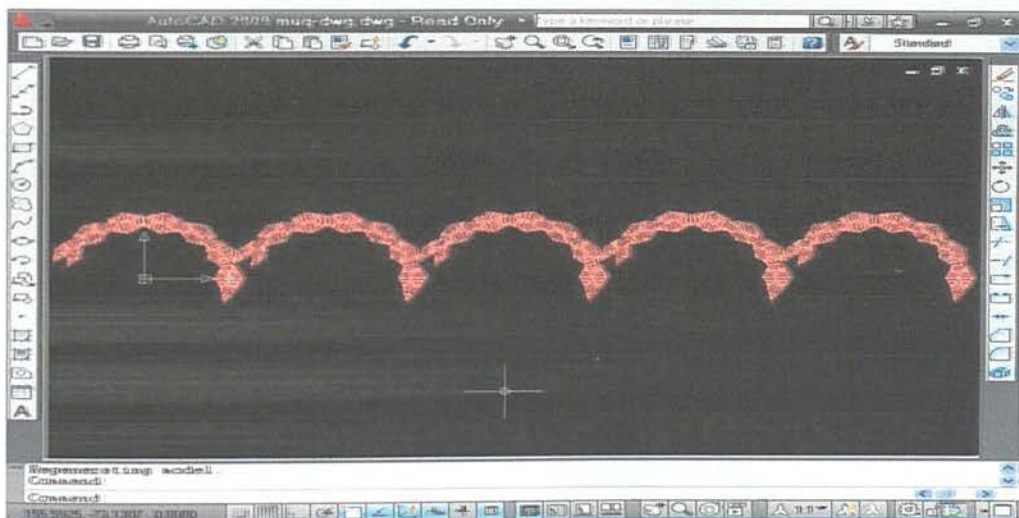


Fig. 5.68. Array to select image



When the angle changes, the 3D wireframe image vision will change, as Fig. (5.69).

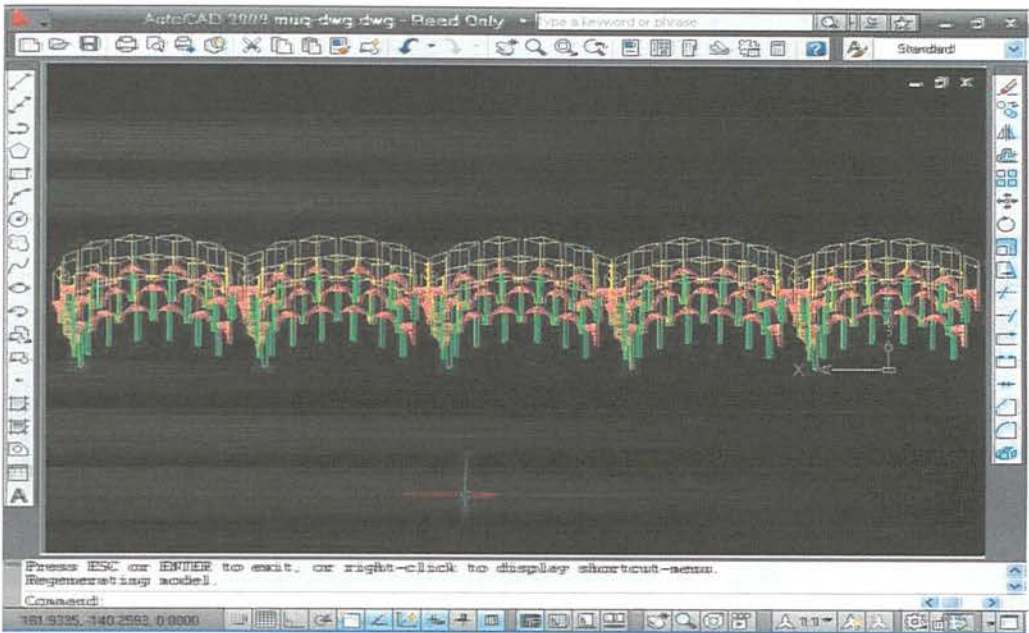


Fig. 5.69. Angle of array

When the 3D hidden angle changes, the image vision will change, as Fig. (5.70).

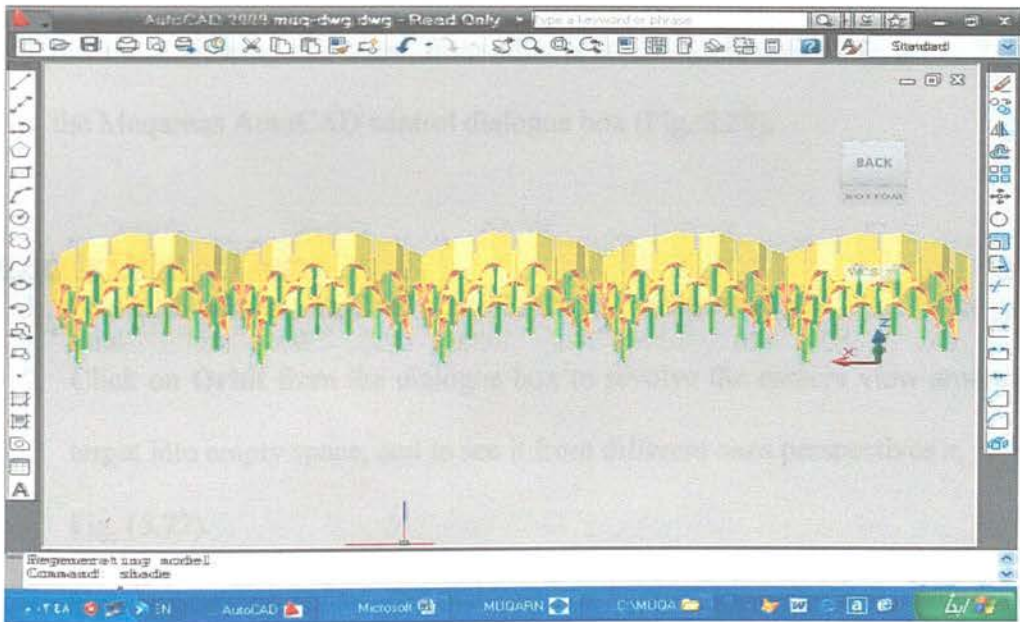


Fig. 5.70. Hidden angle of array

The realistic image vision changes, as Fig. (5.71).



Fig. 5.71. The realistic image vision

The user can continue to create more units, or revolve the camera view around its target, by using empty space or void navigation to create a muqarnas example. It is also possible to continuously enlarge or shrink the view by moving the mouse, and bring the entire drawing into view, from other selection tools such as **Orbit** or **Zoom**, from the Muqarnas AutoCAD control dialogue box (Fig. 5.29).

### To Apply Orbit or Zoom

1. Select Muqarnas AutoCAD control from the sub-menu bar.
2. Click on **Orbit** from the dialogue box to revolve the camera view around its target into empty space, and to see it from different axes perspectives  $x$ ,  $y$ ,  $z$ , as Fig. (5.72).
3. Or Click on **Zoom** from the dialogue box to enlarge or shrink the entire view in increments from Zoom In and Zoom Out, as Fig. (5.72).
4. Click OK to set the target, or X or Cancel to close.

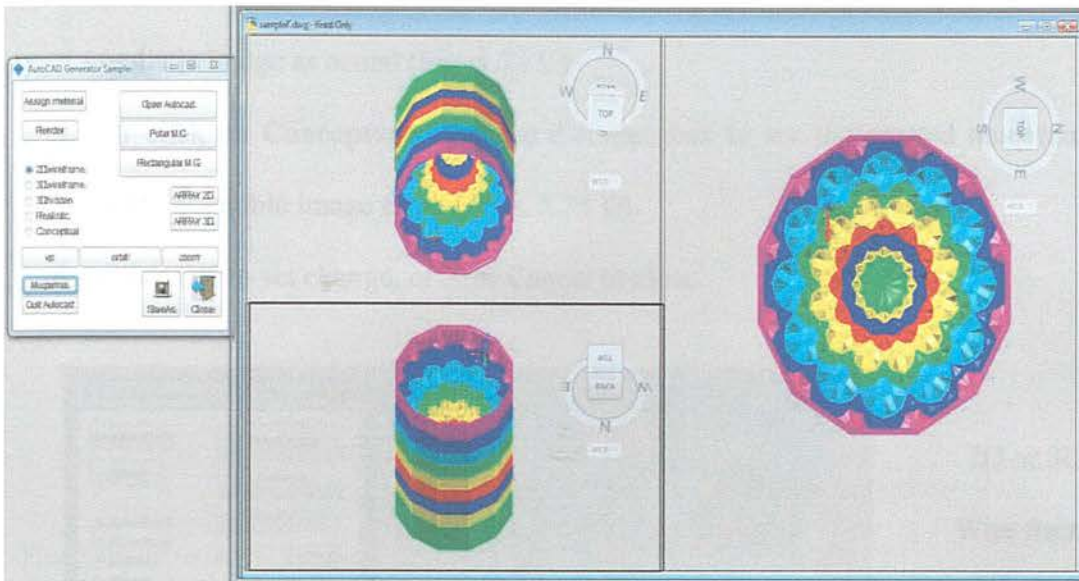


Fig. 5.72. Orbit and Zoom for brings the entire drawing into view

**Note:** If the program did not show the main window and the window covered by AutoCAD, it can switch by using (Alt + Tab) keys together.

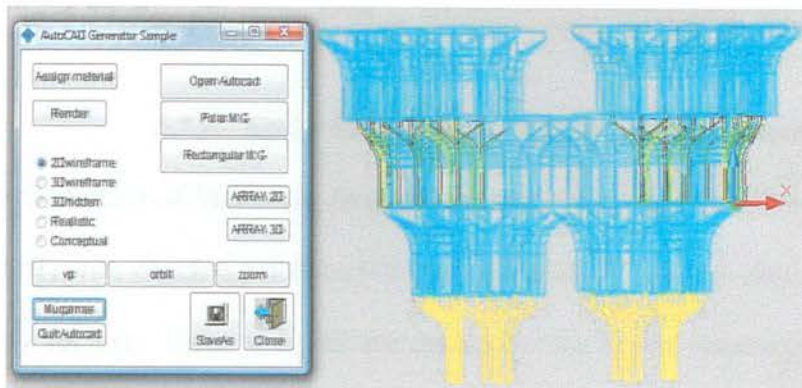
Then, the user can continue to create different viewing units of the created muqarnas example from the Muqarnas AutoCAD control dialogue box, using selection tools such as 2DWire frame, 3DWire frame, 3DHidden, Realistic and Conceptual, forms (Fig. 5.29).

To apply Redo-box: **2D or 3DWire frame, 3DHidden, Realistic and Conceptual** from the dialogue box of Muqarnas AutoCAD control (Fig. 5.29).

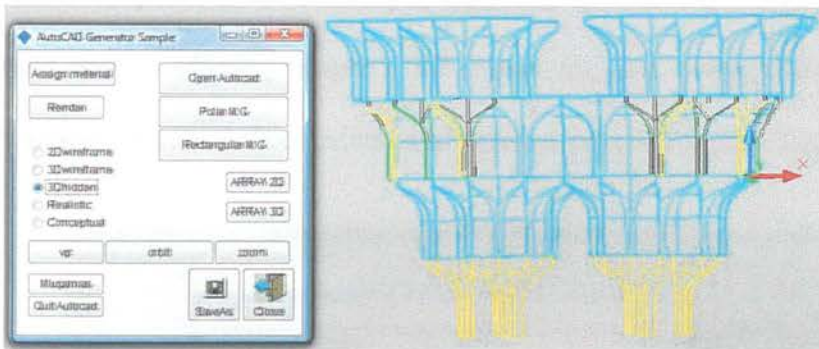
1. Select Muqarnas AutoCAD control from the sub-menu bar.
2. Click on **2D or 3DWire frame** from the dialogue box to see the created muqarnas with wire frames (Fig. 5.73 A).
3. Or click on **3DHidden** from the dialogue box to see the created muqarnas with hidden frames (Fig. 5.73 B).



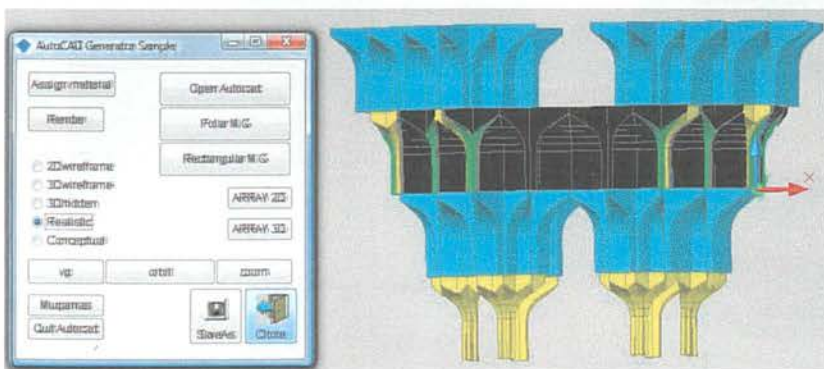
4. Or click on **Realistic** from the dialogue box to see the created muqarnas with realistic image as actual (Fig. 5.73 C).
5. Or click on **Conceptual** from the dialogue box to see the created muqarnas with intangible image as real (Fig. 5.73 D).
6. Click OK to set change, or X or Cancel to close.



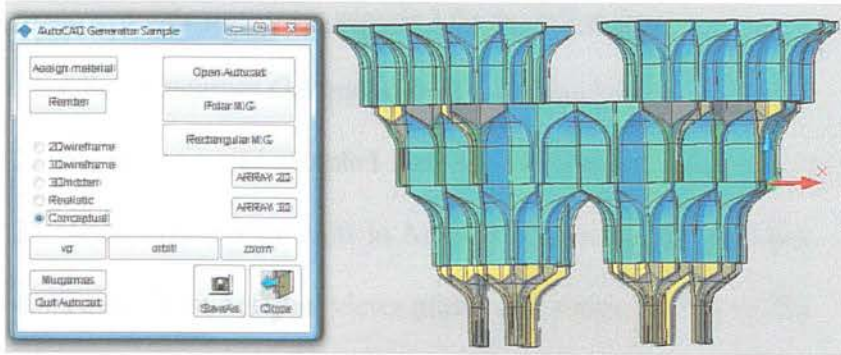
2D or 3D  
Wire frame  
Fig. 5.73. A



3DHidden  
Fig. 5.73. B



Realistic  
Fig. 5.73. C



Conceptual

Fig. 5.73. D

Fig. 5.73. Sample view of 2D or 3DWire frame, 3DHidden, Realistic and Conceptual

#### 5.7.4. Apply Generator of Muqarnas from generated samples

The Generator of Muqarnas program provides three samples (Generated Sample I, II and III) with which the user can be use them directly into any objects and having them ready for use. These samples are driven by the author intention to reintroduce the classical muqarnas in a new version by using this software. The generate muqarnas sample start by offering sample I, will create one unit of muqarnas in AutoCAD and can be seen it from deferent views and deferent plan of types, as Fig. (5.74).

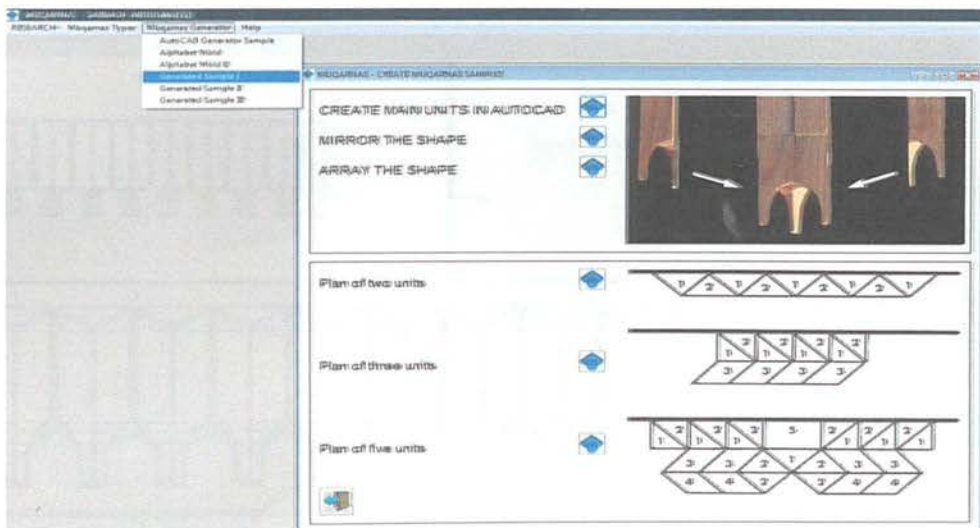
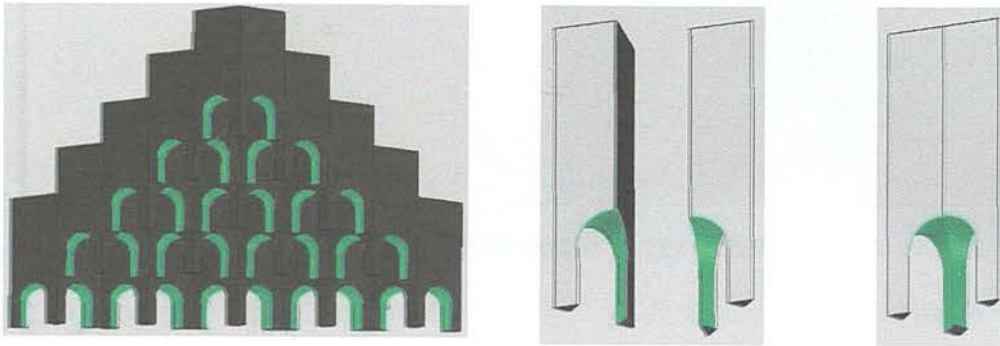


Fig. 5.74. Generated sample I

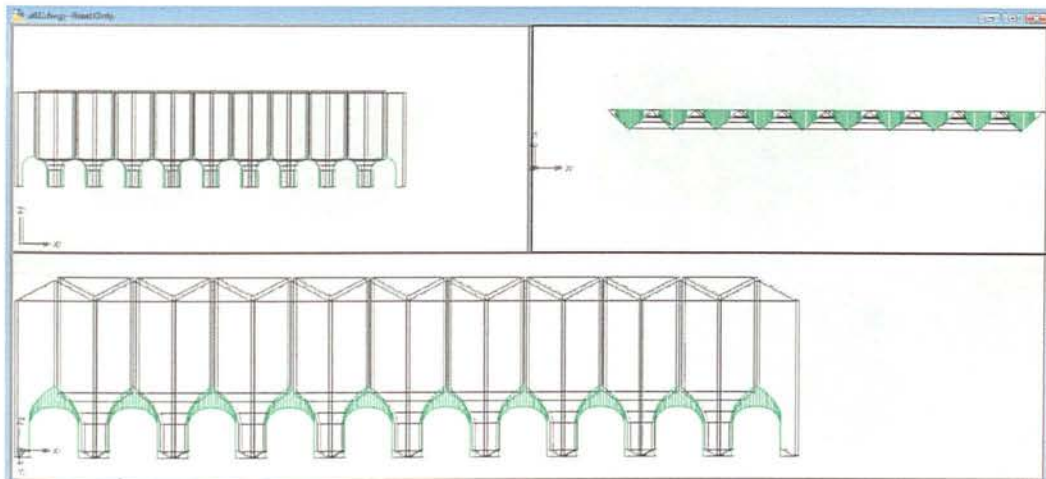
**To create generate muqarnas sample I do the following:**

1. Click Muqarnas Generator from the menu bar.
2. Select generated sample I from the menu list.
3. Select create main units in AutoCAD from the dialogue box.
4. To see from deferent views mirror and Array, as Fig. (5.75).



**Fig. 5.75. Generated sample I from deferent views mirror and Array.**

5. Or anthers selection the plan of two units from the dialogue box.
6. To see from deferent views, as Fig. (5.76).



**Fig. 5.76. The plan of two units from deferent views.**

7. Or anthers selection the plan of three units from the dialogue box.



8. To see from deferent views, as Fig. (5.77).

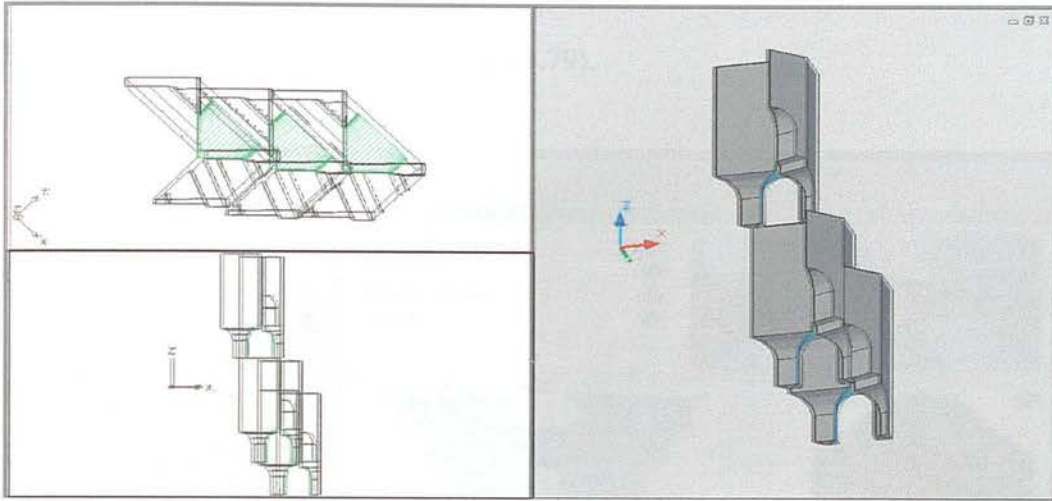


Fig. 5.77. The plan of three units from deferent views.

9. Or anthers selection the plan of five units from the dialogue box.

10. To see from deferent views, as Fig. (5.78).

11. Select close in the right corner or click X in the upper right corner of the dialogue box.

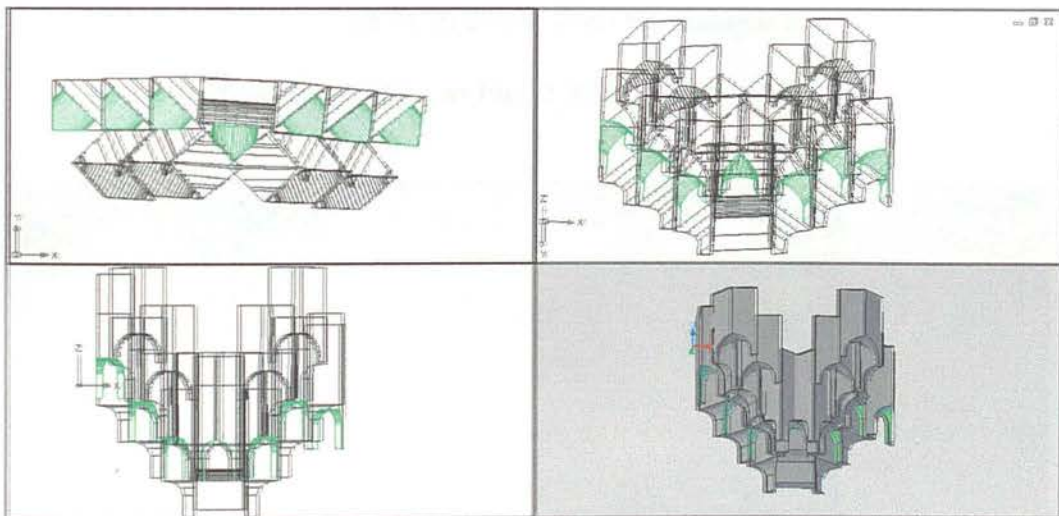


Fig. 5.78. The plan of five units from deferent views.

Another sample of generate muqarnas, sample II, will create group of muqarnas units in angle of 30 degree, in flat grade, in mihrab, portal, column, capital and in dome, and can be seen from deferent views Fig. (5.79).

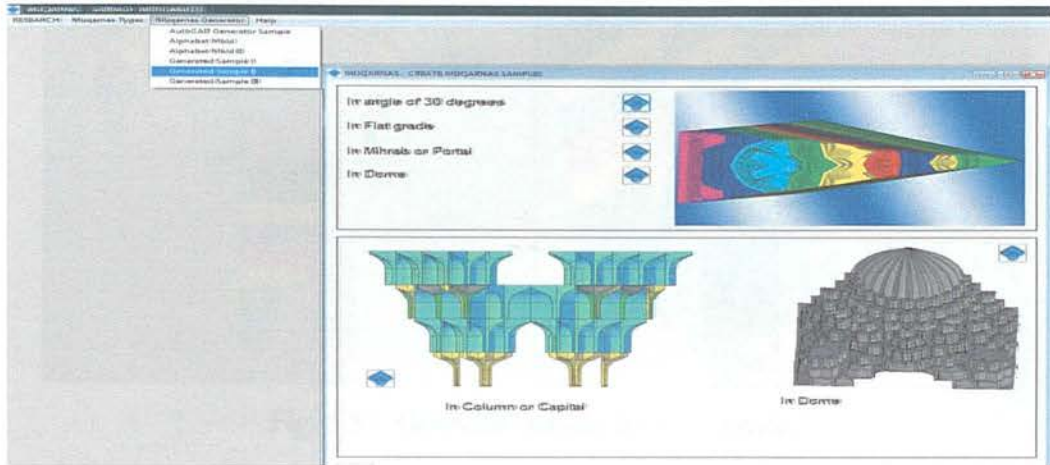


Fig. 5.79. Generated sample II

To create generate muqarnas sample II do the following:

1. Click Muqarnas Generator from the menu bar.
2. Select generated sample II from the menu list.
3. Select generate in angle of 30 degree from the dialogue box.
4. To see from deferent views, as Fig. (5.80).

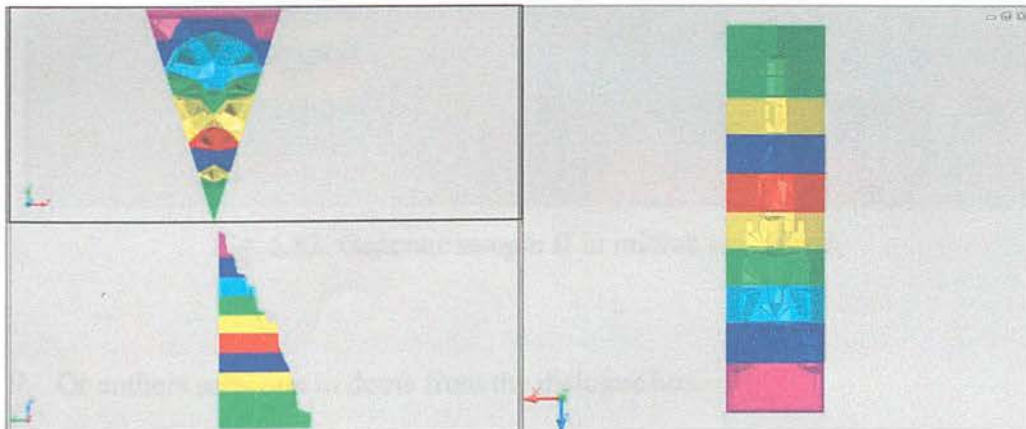


Fig. 5.80. Generate sample II in angle of 30 degree.

5. Or anthers selection in flat grade from the dialogue box.
6. To see from deferent views, as Fig. (5.81).

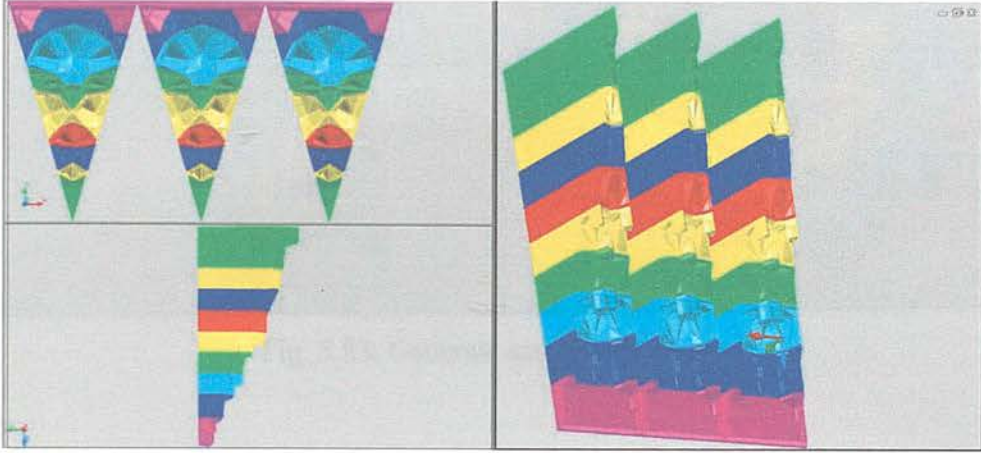


Fig. 5.81. Generate **sample II** in flat grade.

7. Or anthers selection in mihrab and portal from the dialogue box.
8. To see from deferent views, as Fig. (5.82).



Fig. 5.82. Generate **sample II** in mihrab and portal.

9. Or anthers selection in dome from the dialogue box.
10. To see from deferent views, as Fig. (5.83).



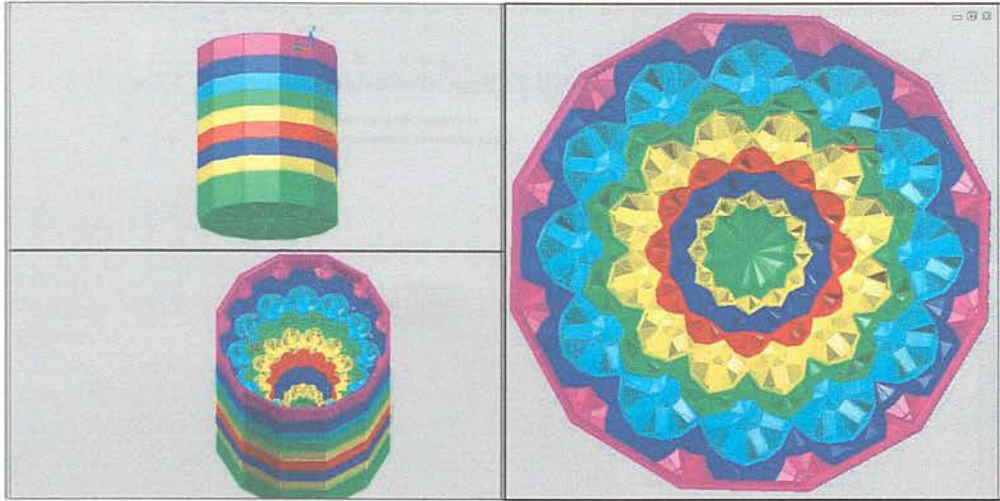


Fig. 5.83. Generate **sample II** in dome.

11. Or anthers selection of the dome from the dialogue box.
12. To see from deferent views, such as 3D hidden and conceptual as Fig. (5.84).
13. Select close in the right corner or click X in the upper right corner of the dialogue box.

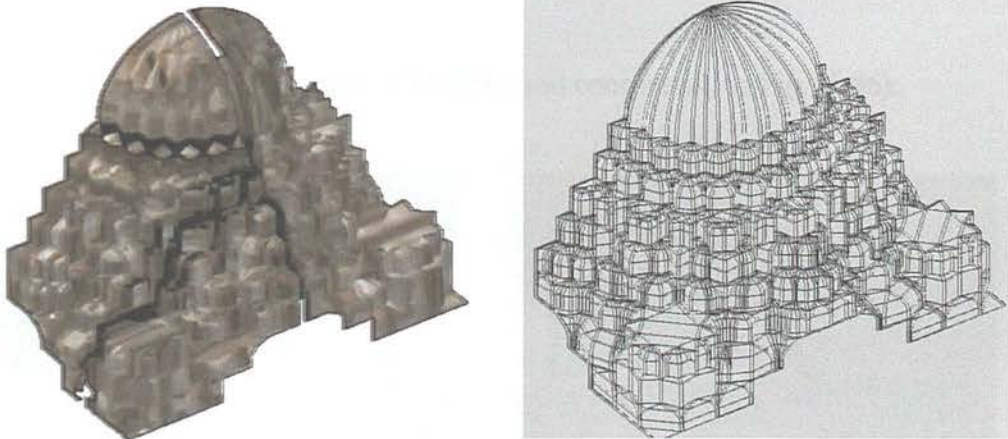


Fig. 5.84. Generate **sample II** in dome from 3D hidden and conceptual.

Another sample of generate muqarnas, **sample III**, will create group of muqarnas units, as raised-out and deep-set of muqarnas Fig. (5.85).

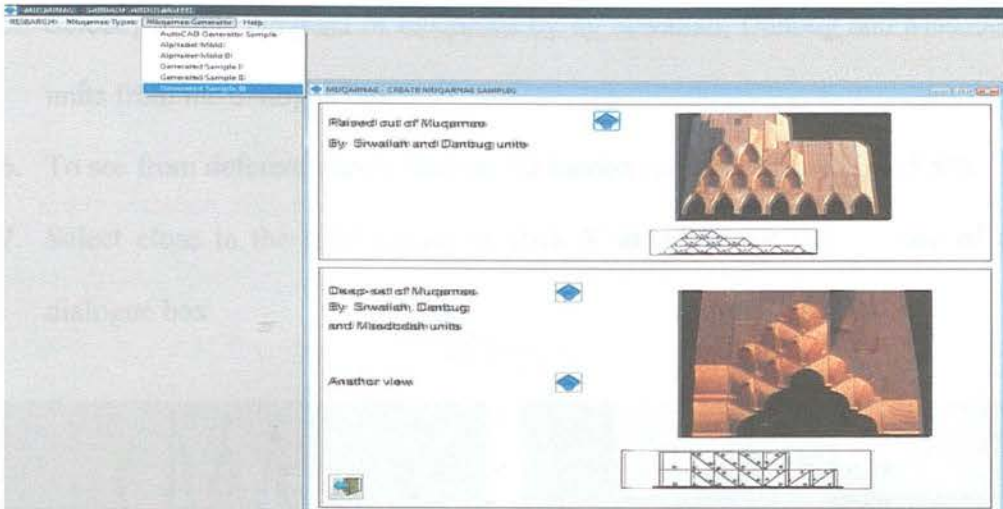


Fig. 5.85 Generated sample II

To create generate muqarnas sample III do the following:

1. Click Muqarnas Generator from the menu bar.
2. Select generated sample III from the menu list.
3. Select generate raised-out of muqarnas by Srwaliah and Danbug units from the dialogue box.
4. To see from deferent views 3D hidden and conceptual, as Fig. (5.86).

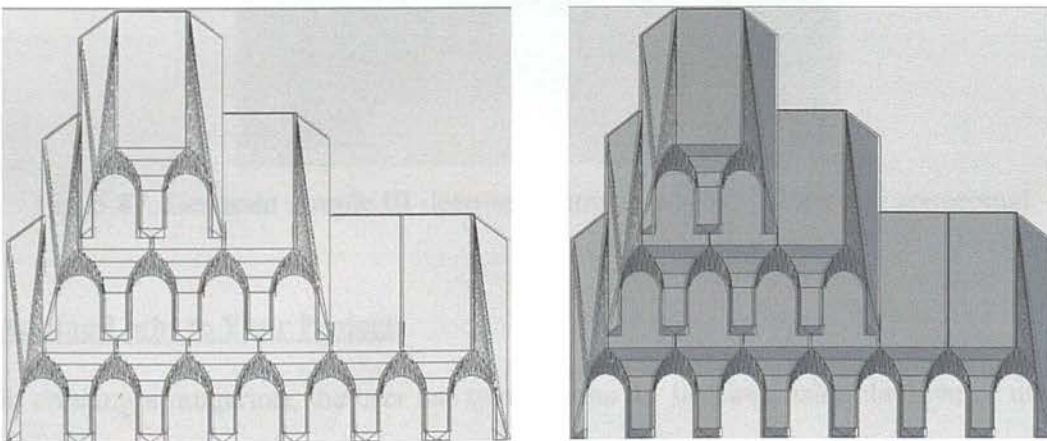
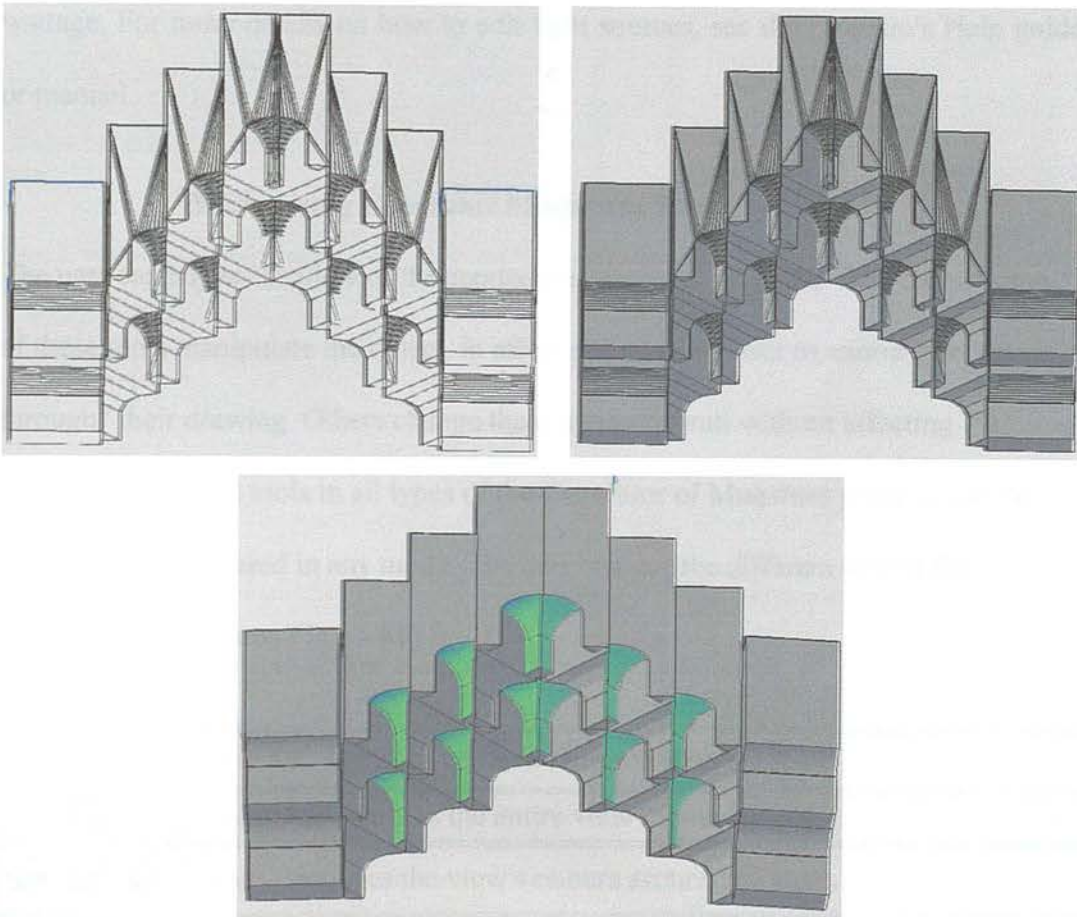


Fig. 5.86. Generate **sample III** raised-out of muqarnas, 3D hidden and conceptual.

5. Select generate deep-set of muqarnas by by Srwaliah, Danbug and Masdodah units from the dialogue box.
6. To see from deferent views, such as 3D hidden and conceptual Fig. (5.87).
7. Select close in the right corner or click X in the upper right corner of the dialogue box.



**Fig. 5.87. Generate sample III deep-set of muqarnas, 3D hidden and conceptual.**

### **Adding Light to Your Project**

In creating a muqarnas, the user has two options for lighting, using daylight or using artificial light. If daylight is chosen, the program will light the project inside and out using only light from the sun (as if all the lighting objects in your project are turned











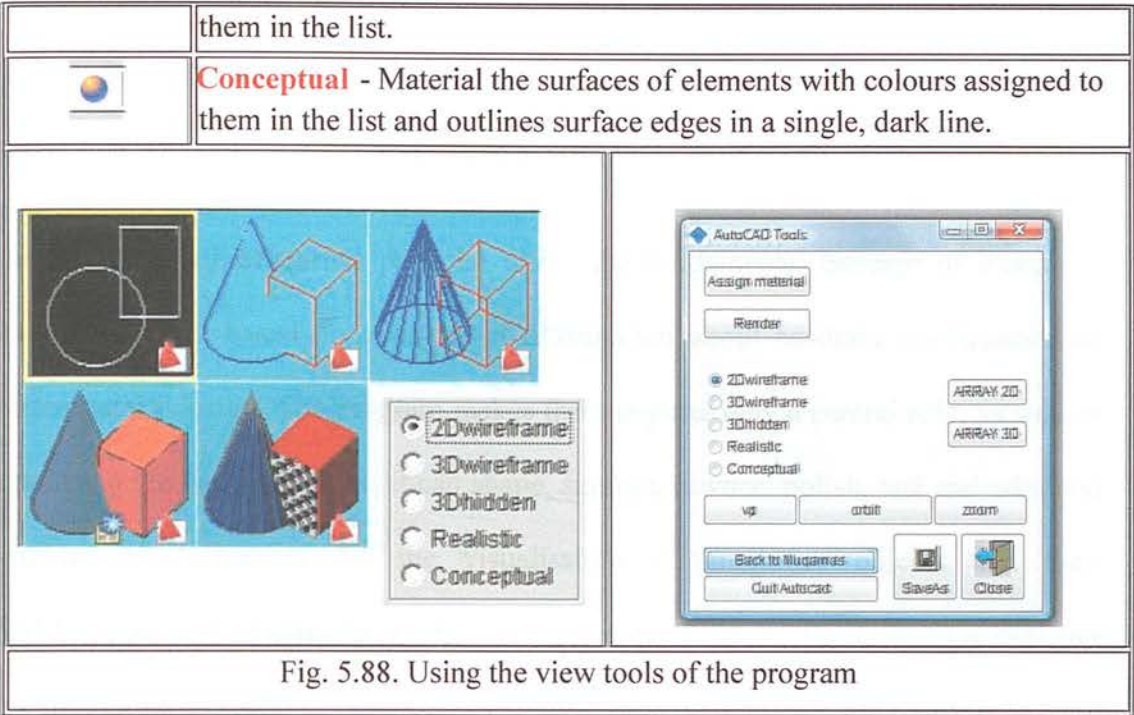
off). If the user chooses not to use daylight, the program will use the lighting elements placed in the project, but will not use daylight as a source.

**Note:** Some fixtures, like wall sconces and ceiling lights, are dependent on another structure. Before inserting them in a drawing, make sure there is a wall or ceiling to attach them to. Advanced users can go so far as to change the light element's type and wattage. For more details on how to edit light sources, see the program's Help guide or manual.

5.7.5. Using Generator Muqarnas Tools

The user can adjust the view of the created muqarnas by using the view tools. Some of these tools manipulate the object, in effect allowing the user to animate or "create through" their drawing. Others change the drawing overall without affecting the object position. All tools in all types of the Generator of Muqarnas program can be automatically rendered in any mode. The user can use the different modes for a variety of applications Fig. (5.88).

	<b>Zoom In</b> - enlarges the entire view in increments.
	<b>Zoom Out</b> - shrinks the entire view in increments.
	<b>Orbit</b> - revolves the view's camera around its target.
	<b>Rendered (2D &amp; 3DView)</b> - Shows a photo-realistic rendering of user project.
	<b>Render Array</b> - Displays the subdivided surfaces used in the Image-realistic display of your project. This is useful when determining the level of detail speed of rendering relationship.
	<b>Wire frame</b> - In 3D view, a representation of elements that lets user see through them to view their entire composition
	<b>Hidden Line</b> - Hides lines that you would not normally be able to see. This is a more realistic view than Wire frame.
	<b>Realistic</b> - Material the surfaces of elements with colours assigned to



5.8. Conclusion of Chapter Five

The research has demonstrated the application of the Generator of Muqarnas program to extend the use of muqarnas in Islamic culture for landscapes, townscapes, internal architectures, furniture, and so on. The author strongly believes that Arabic-Islamic cultural heritage has left us a legacy that helps us to continue the expression of our culture, using architectural designs to conform and respond to people, nature, and aesthetics, in order to produce muqarnas designs in different styles, from modernist to postmodernist to high-tech art. This was what motivated the author to explore muqarnas in this work.

This chapter has described and exhibited the Generator of Muqarnas program, as the basis of the author’s intention to produce a computerised version of the muqarnas, while preserving those attributes which are important to maintaining the function of the muqarnas as a structure. The author believes that the muqarnas is a living system

which involves an evolutionary process of growth and change with design movements. He has found the modern muqarnas with creative technology, by developing a muqarnas software program.

The Generator of Muqarnas program offers the fundamental concept of muqarnas design as a tool, based on volumes of information about aesthetic preferences for contemporary design. The program makes the computer play a central role; as well as supporting the design process, it can shape, smooth, rework, polish, test and edit, and provides a mechanism for the visualisation of muqarnas objects and their modifications and extensions on all levels, in order to move the muqarnas designer one step closer to reality.

The Generator of Muqarnas program uses the facilities of the AutoCAD program for the establishment of the required design, by using its automated tools to guide the user through the display of the muqarnas views. The program offers an unlimited use for the creation of muqarnas and this is a great advantage.

The user needs to learn many shortcuts or icons in order to achieve a certain result. The view of the Generator of Muqarnas program starts on the desktop screen where the main menu bar offers alternatives such as: Research, Muqarnas Types, Muqarnas Generator and Help. Then each menu has a different selection concerning the programming construction of the side view. The Research contents of a folder are displayed as a list of chapter files of this thesis, making reading chapters on the screen more comfortable and linking them with the program.



The Muqarnas Types contains the types of muqarnas, such as Shami and Baladi. Each type has three sub-type models: Plainer, Composite and Stalactite. The user can work in both 2D and 3D views.

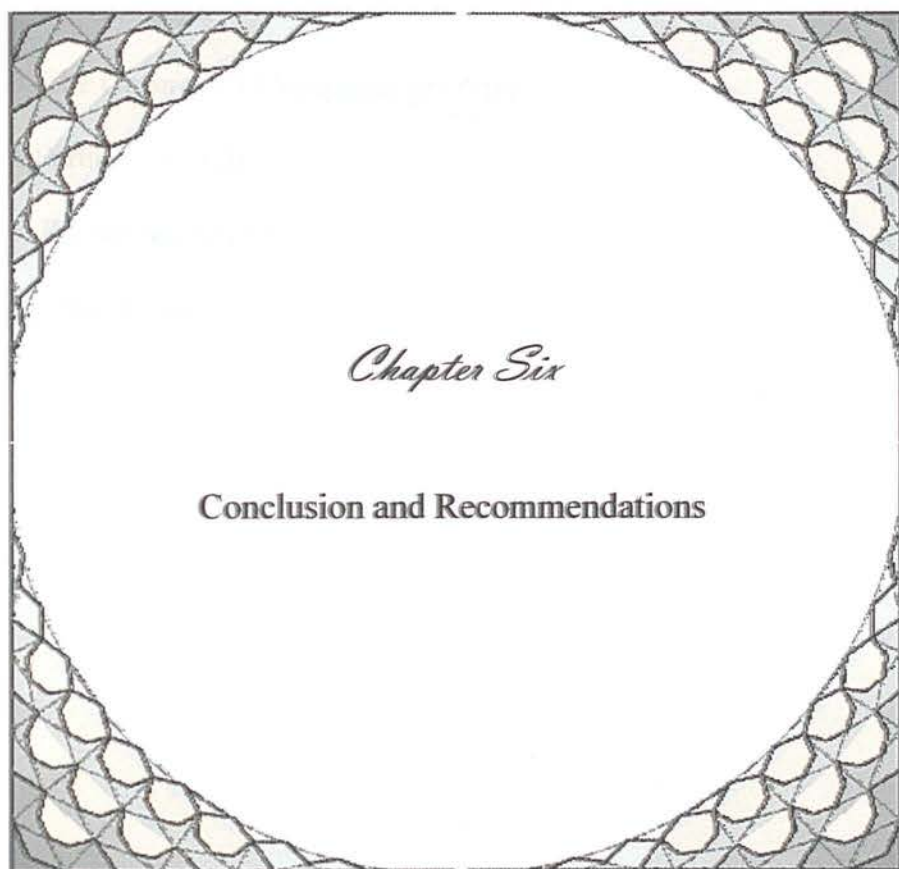
The Muqarnas Generator view displays the AutoCAD generator sample and each generator has a choice of Alphabet Mould or Generator Sample 1, 2 or 3 in a separate dialogue box that allows the user to create muqarnas units.

The last view is the Help, which is the navigator for the program, and contains the Muqarnas Generator Help and About information, which provides the user with help in using the program, and also guides them to all the program's icon information.

It is hoped that this chapter has made clear the basis of transforming the muqarnas using the computerised program for contemporary design. The achievement may bring in a new age of art, creating a new generation of muqarnas, and it has reached a stage where it could mean a lot in the art world by making changes in the history of the muqarnas using creative technology.

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i - Paccard, A. (1981) [This illustration is a screen of one of the rooms in the dome of the two Sisters hall in the al-Hambra palace, in Granada in Spain, to be diffused in the muqarnas motif].



## **Chapter Six: Conclusion and Recommendations**

6.1. Overview of the thesis

6.2. The findings

6.3. The Generator of Muqarnas program

6.4 Further research

6.5. Recommendations

6.6. Final words



## Chapter Six: Conclusion and Recommendations

### 6.1. Overview of the thesis

This conclusion summarises the understanding and interpretation of the muqarnas as an artefact in Islamic decoration, through the application of structural transformation in Islamic art and architecture using structuralism. This approach has emphasised the geometric techniques that facilitated this transformation, and has provided a software version on the basis of making a contribution to the muqarnas design process by allowing production within new technological forms.

The overall view expressed in this research is that the muqarnas is a phenomenon that is part of the structure and decorative finishing strip and its features and ornamentation. It has deep roots in all aspects of Muslim art, as an architectural feature, decorative motif, cultural expression and aesthetic, and symbolic meaning in an enriched block or horizontal bracket, adding to the appreciation of the quality of the environment.

This thesis has attempted to open gates to creative thinking about many of the ideas and concepts of designing muqarnas. It is believed that producing a software version for new muqarnas technology will be a significant contribution to the design process and will influence the way people create the muqarnas and maintain its role. There has been extensive interest in the study of muqarnas as a design from an objective point of view, with consideration given to building on traditional design elements

using scientific technology. The muqarnas is an Islamic innovation used as a means of exploring the cultural and compositional units (cube, sphere, wall, columns and arches) and the properties of the organic rules of the muqarnas on a plane with a different orientation. This Islamic ornamentation is one of the outstanding expressions of Islamic artistic creativity, and has various roles in design as a complex geometric interlacing of components, producing a three-dimensional surface using concave elements.

The purpose of chapter two was to show how this unique feature of Islamic architecture is used both for architecture and ornamentation, as a decorative motif and as an enriched block or horizontal bracket, as a kind of corbel. These are particularly known as a means of going from a nearly vertical square form to a spherical form whose base is a circle. While the Romans used hanging elements for this purpose, the Arabs have chosen the approach of muqarnas as a support for the cupola. It is found under the cornice and above the bed-mould of Corinthian entablature, as a type of structure and construction of a decorative finishing strip, and at the same time, it hides the transitional zones between various surfaces (e.g. arches, domes, capitals, windows, ceilings, minarets, mihrabs, minbar and façade).

The aesthetic quality of the muqarnas became a consistent feature of Islamic architecture. The muqarnas is one of the distinguishing features of Islamic architecture, revealing a strong disposition to develop, innovate, and create. Such as constructive the layers of muqarnas side-to-side, in which small niche-like components are combined with each other in successive layers, to produce surfaces rich in three-dimensional geometric patterns. The epigraphic design and art that adorn

the ceiling and friezes in Islamic buildings remain the basic component of architectural creativity. The origin of the muqarnas can be seen in the stalactites formed by water dripping inside caves forming superb and admirable shapes. The expression of this beauty has come into architecture in the muqarnas whose motifs give the same impression as natural stalactites.

The study discussed how the muqarnas originated in a number of Middle Eastern countries such as Iran, Iraq, Syria and Egypt. The earliest examples of muqarnas so far discovered were found at *Nishapur* in eastern Iran and date from the late 9<sup>th</sup> or early 10<sup>th</sup> century, and the oldest examples in *Riga*, in Syria, date from the 8<sup>th</sup> century. Another surviving example found in *Khurasan* in northeast Iran dates to the 10<sup>th</sup> century. This feature then spread throughout the Islamic world, and was developed in the mid-10<sup>th</sup> century in Iraq, when that region was the homeland of the Abbasid caliphate. The muqarnas became one of the defining elements of Islamic architecture from the 12<sup>th</sup> century in Syria, Egypt and Turkey. During the 11<sup>th</sup> century muqarnas spread to most parts of the Middle East (from Egypt to Central Asia). In the western Islamic world, for example in North Africa, a similar device called '*muqarbras*' was also used. Admirable examples have been found in Egypt that go back to the time of the Mamluks and Seljuks and are carved into the stone. The use of muqarnas culminated in Spanish Islamic 'Andalusia' and Turkey during the Ottoman Empire. The most fabulous examples are those of the Alhambra in Cordoba in Spain and in a number of the Ottoman buildings throughout the Islamic world.

Chapter Two also discussed a number of materials used in building muqarnas, which were constructed from local materials such as stone, brick or stucco. The material

might be left as it was or covered with coloured ceramic, as in the Persian Islamic structures, or with glass, as in certain Islamic structures in Najaf and Karbala, in Iraq, or with marble, as in Turkey during the Ottoman era. They might be built of wood and form decorative motifs allied to certain ceramic elements, as at the peak of the entrance to a pulpit, or in certain furnishings, as found in Syria, Egypt, Morocco, Spain, southern Italy<sup>i</sup> and the UK<sup>ii</sup>.

Chapter three introduced a detailed study and analysis that explained a range of essential ways of dealing with the interrelation of proportions to ensure a harmonic proportionality of each element of the muqarnas units in Islamic architecture, through an evaluation of the methods of handling it. There are different methods for dealing with the muqarnas ratios according to their idealistic position and the justification of their application. The harmony of the arrangement of the system of lines and arches in the formation of the muqarnas demonstrates the static and absolute principles in the design of muqarnas. Their beauty is created through the shaping and creativity in the diversity of forms, including the sphere angle corner or spherical triangle (Shami), or prismatic composite triangle (Baladi) or stalactite form, or through a combination of these.

The study discussed a number of concepts connected to structuralism. The theoretical study in chapter four showed the characteristic principles of the intellectual and subjective attributes related to the muqarnas properties, concentrating on structural transformation in Islamic art and architecture using structuralism and associated theories. In addition to this the chapter showed how Muslim architecture, with its artistic combination of Islamic principles and the architectonic form of muqarnas, will

help many Muslims to keep their spiritual vision in focus and to regain the aesthetic qualities of their universal Islamic consciousness, their sense of identity and their sense of direction. Islamic values are indivisibly linked to art.

This research has concentrated attention on the importance of the study of the aesthetic and symbolic values which result from the transformation from the deep structure into the surface structure, because it represents meaning. This gives rise to the claims of the study that the muqarnas identity and structure are the result of an evolutionary process.

Chapter five describes and exhibits the Generator of Muqarnas program, as the basis of the author's intention to produce a computerised version of the muqarnas which maintains those attributes that are important in preserving the function of the muqarnas as a structure. According to the author's belief, the muqarnas is a living process, which involves growth and change with design movements. This movement in using technology intends to maintain the muqarnas identity and structure as a result of an evolutionary process. This has been achieved by developing a muqarnas software program.

## **6.2. The findings**

The findings of the present research emerge from its historical, theoretical and empirical aspects. The purpose of this study is to discuss the findings coming from the application of historical and theoretical analysis to the muqarnas, in terms of their basic elements and ratios based on the proportional order and harmony of each element in various surfaces of Islamic architecture. In other words, it aims to provide

a notion of structure and construction decoration, and introduce change into the muqarnas phenomenon, transforming it to suit modern demands and use.

The muqarnas is not only a feature of Islamic architecture used as a decorative motif or as an architectonic form, it also represents qualities found in Islamic art, including creativity, intelligence, resoluteness and vitality. It is a symbolic motif of the Muslim community, with a social, cultural and symbolic meaning in keeping with the function of the object or decoration.

It was observed throughout the study that one of the most influential parameters affecting the rules of the muqarnas across different eras was the skill in people's hands, in sensing the forces that were working in shaping form, and the principle of creation that commands those forces. Thus achievement of the rules of geometric decoration was made possible in the muqarnas, through the interest generated by mathematical studies, such as Pythagorean mathematics. Starting from the circle, an extraordinary variety of figures were generated (squares, diamonds or rhombuses, hexagons, octagons, stars with six, eight, ten, twelve and more points) by applying the principles of symmetrical repetition, multiplication or subdivision in any material and on any scale. Thus rules are responsible for producing and expressing the mathematical and geometrical structures in the computerised version of the muqarnas.

Moreover, the author has become aware of the bond between beauty and perfection, which go together in Islamic art, reflecting the extent of the perseverance of the basic principles that determine the values of ratios and proportionality. The beauty of architecture is controlled by aesthetic units, which is one of the most outstanding



characteristics of Islamic architecture. It is contained in the aesthetic units for the formation of the muqarnas, in ratios which are acceptable to Islamic artistic taste, such as 1: 1, 1: 1.5, 1: 1.33, 1: 1.25, 1: 1.125, etc. These ratios define the muqarnas as decorative elements.

The study of muqarnas design attempted to relate the objective phenomena of the muqarnas, as expressed in its Islamic architectural and art contexts (surface structure), to its subjective meaning as represented in various cultural, sentimental and symbolic values (deep structure). In other words, surface structure represents the building of the muqarnas itself, its ornamentation and decoration, and all the visible aspects. Deep structure represents the meaning and the forces responsible for producing a particular design in a particular place. It was shown in chapter four that issues of the identity and structure of the muqarnas have concentrated attention on the significance of structuralism, and on important intellectual aspects related to the meaning and symbolism of the muqarnas. This identity has rules based on culture, continuity, aesthetics, taste and meaning. These include the aesthetics and symbolism which arise as a result of the surface structure and its transformation of the deep structure to present its meaning.

Moreover, the deep symbolic form of the muqarnas is identified with the symbolic form of a less concave niche or a small Mihrab, which has different sentimental meanings, such as veneration of place, a feeling that is inviting but demands discretion, signifying a door opening onto the divine world and passing through to an otherworldly experience. It sends the vision to the other world, that of the infinite, raising an image of passage towards God, by means of the idea that the Prophet

Muhammad (Peace Be Upon Him) experienced on his night journey '*Isra*' followed by the heavenly ascension '*Mi'raj*', when he passed through the seven heavens, reached the Throne and approached God<sup>iii</sup>. This is followed by the inscription recalling the Throne of Allah Almighty (Fig. 6.1).

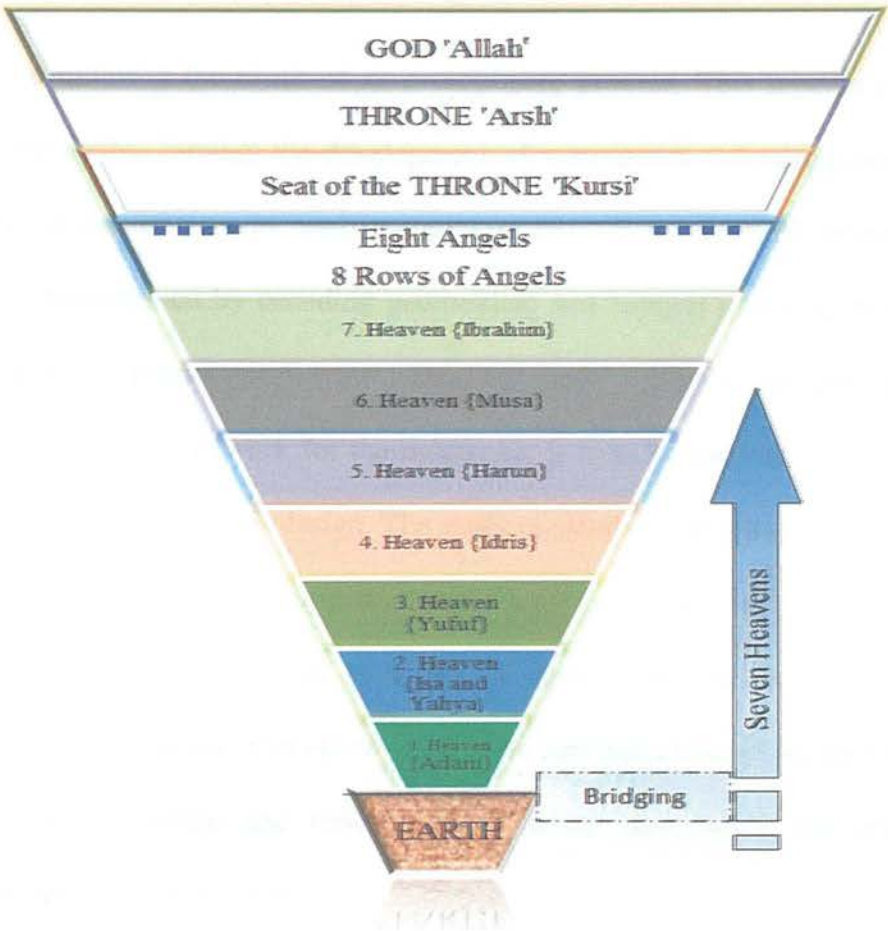


Fig. 6.1. Cosmological model according to the *hadith* of the Mi'raj

Cosmologically, the forms of the muqarnas are the transition from Earth (the square underneath the circle) to the domed celestial, to the Throne (the octagonal zone) to God One. Spiritually, the muqarnas symbolises the stars in the sky, being a model for the open horizon and spherical sky that have no pillars. It represents the union of

Earth with Heaven; the lines of force meet at an angle with a reaction line at the keystone running out of the top of the structure, while the growth of the pointed arch along a horizontal axis in each muqarnas form indicates the connection between the earth and the sky. This is reflected in the many forms of the muqarnas and can be applied to the majority of other muqarnas elements.

Chapter five followed the result of an evolutionary process. This process has been taken a stage further through the development of a muqarnas software program. By using spreadsheet software to read its transformation from the deep structure, the muqarnas is transformed by encoding geometrical and cultural meaning into hidden rules in creative technological ways. This has been achieved by presenting an application program framework for the muqarnas. It is to be used as a tool to solve specific problems of muqarnas design. The study concluded that muqarnas design is a process of transformation, and suggests that the artist's and the architect's freedom to create contemporary designs will be aided by finding alternatives to the model (muqarnas blocks), in a way that allows each to be assessed, assisted by the computer software, that can rotate and turn over the model and output the expressed transformations fast and accurately.

In the following section it is very important to highlight the significance of a simple software program of the muqarnas, relevant to the field of Islamic architecture, epigraphic design and art such that they can be appreciated by contemporary practitioners, especially contemporary viewers who will find alternatives to the model (muqarnas blocks) in order to assess and have them ready for use as a computerised assistant for producing two- and three-dimensional drawings.



### 6.3. The Generator of Muqarnas program

The current research aimed to build up a clear and consistent image of the muqarnas with the vision of the Islamic artist in combination with the great technological revolution in the application of computer education in (postmodern) Islamic ornamentation art. The same emphasis from using it as a tool to making it integral to the design process as a means of communication preserves the information and technical output. This will have a very profound influence on how artistic visions perceive the quality of muqarnas design.

The Generator of Muqarnas program offers the fundamental concept of muqarnas design as a resource tool project, through volumes of information based on the aesthetic preference for contemporary design. This program makes the computer play a central role: as well as supporting the design process, it allows users to shape, smooth, rework, polish, test and edit their designs, and provides a mechanism for the visualisation of muqarnas objects, and their modifications and extensions on all levels, in order to move the muqarnas designer one step closer to reality.

The Generator of Muqarnas program is an application software, which is used like a tool to create and modify two-dimensional plans and convert them to three-dimensional muqarnas data, then to assess alternative designs and have them ready for use in the form of computerised models. The ideas explored in the research project provided the model for matching with the results of the study analysis, and for the creation of a user interface with which users should be able to edit muqarnas plans on the computer. This program works together with AutoCAD, which allows the creation of

high quality epigraphic types of the muqarnas, and can be widely used both by professionals and amateurs.

The Generator of Muqarnas program is a computer system; it is a set of sequence instructions and a collection of muqarnas data and information, which tell the computer what to do. It is (Logical Component) built on thought, knowledge and planning to create a contemporary muqarnas. It is designed to solve specific kinds of problems with muqarnas designs so that the designer can see the design from all sides.

Accordingly, the author has built a software program for generating the muqarnas automatically, using programming languages such as Microsoft Visual FoxPro, VBA (Visual Basic for Application) and Auto Lisp. This software program will find alternatives ready for use in the form of computer-generated muqarnas drawings which will help the user assess designs, as they are easy to use, saving time and effort. It allows the creation of muqarnas designs in terms of quantity and number, space, materials, colouring and drawing, in order to generate a modern muqarnas and to create a new modern muqarnas identity.

#### **6.4. Further research**

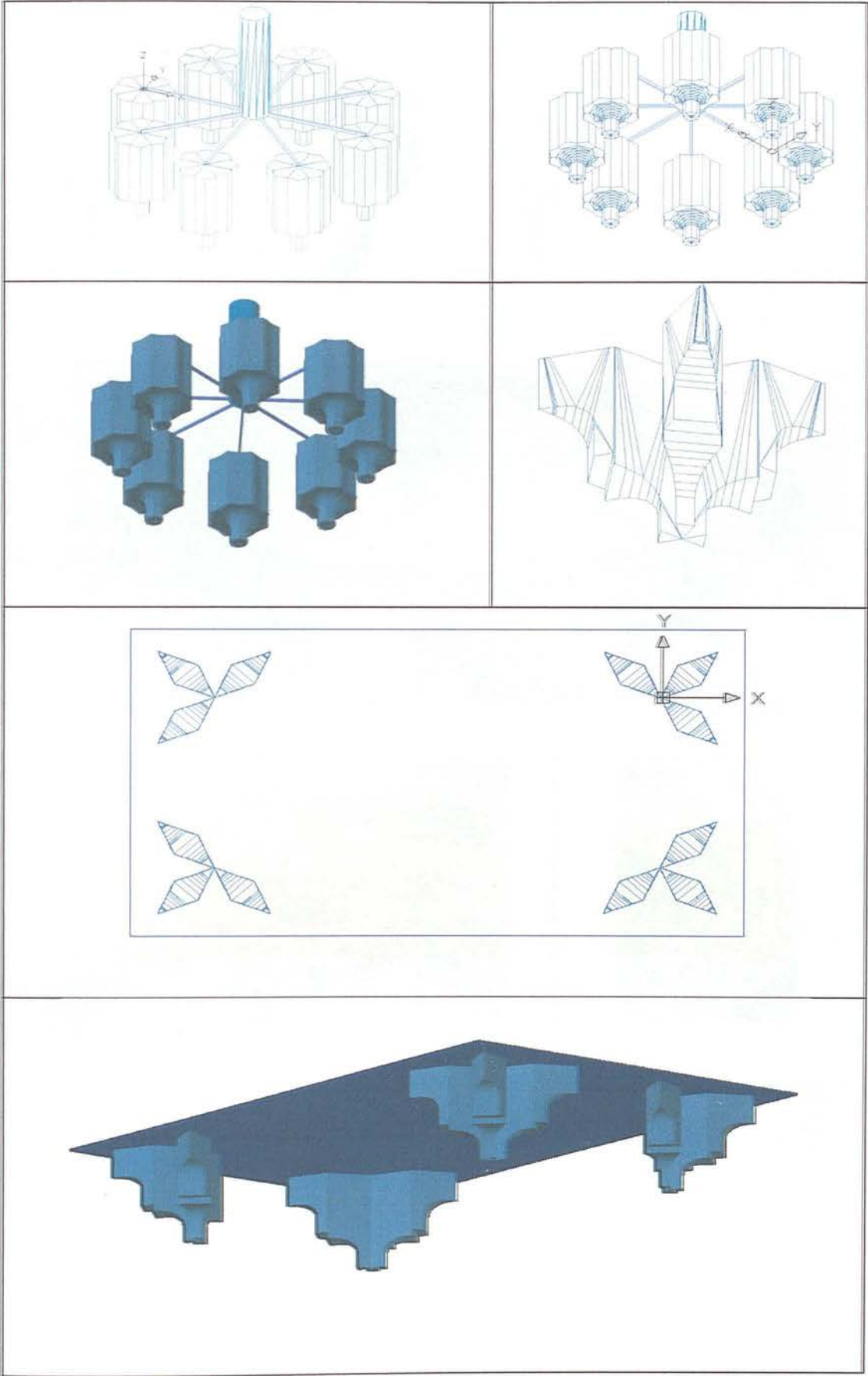
Creative technology affects our moods and lifts our spirits, ultimately contributing to our well-being. Consequently, the quality of decorative muqarnas is a very important factor. Material finishes, vertical and horizontal movement, scale, light and shadows, and colour influence the quality of a muqarnas design.

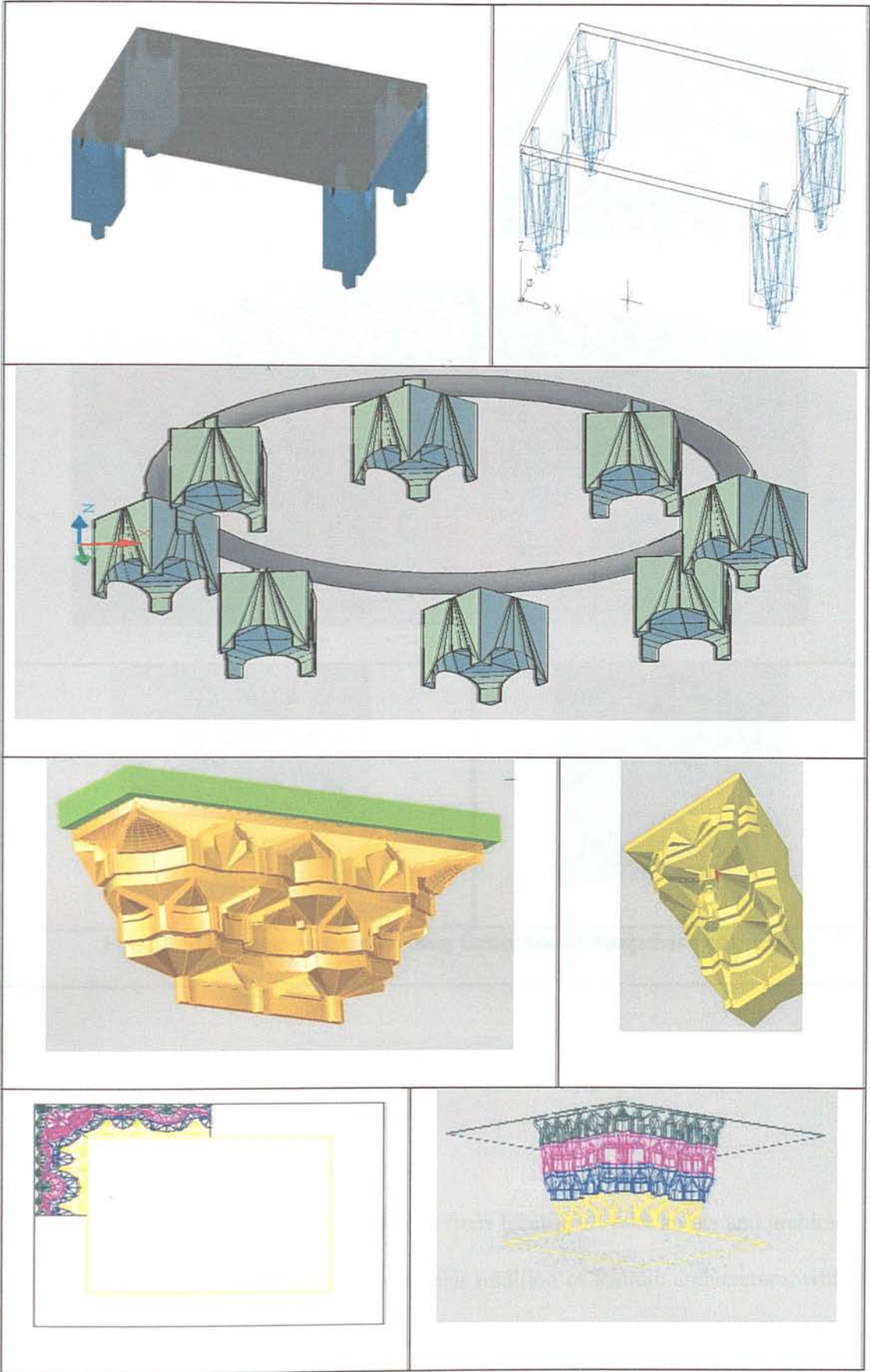
This research has opened a door for exploration and invention into the use of an informal approach to enrich the existing formative component in the muqarnas and its role. It is suggested that the results of this research may take their place alongside other studies as an evaluative tool to be employed in explaining the characteristics of any other design criteria phenomenon by tracing its origins, symbolic deep meaning and transformation. This achievement of producing a computerised version of the muqarnas generator may mean a lot in the Islamic art world and provide for changes in the history of muqarnas design.

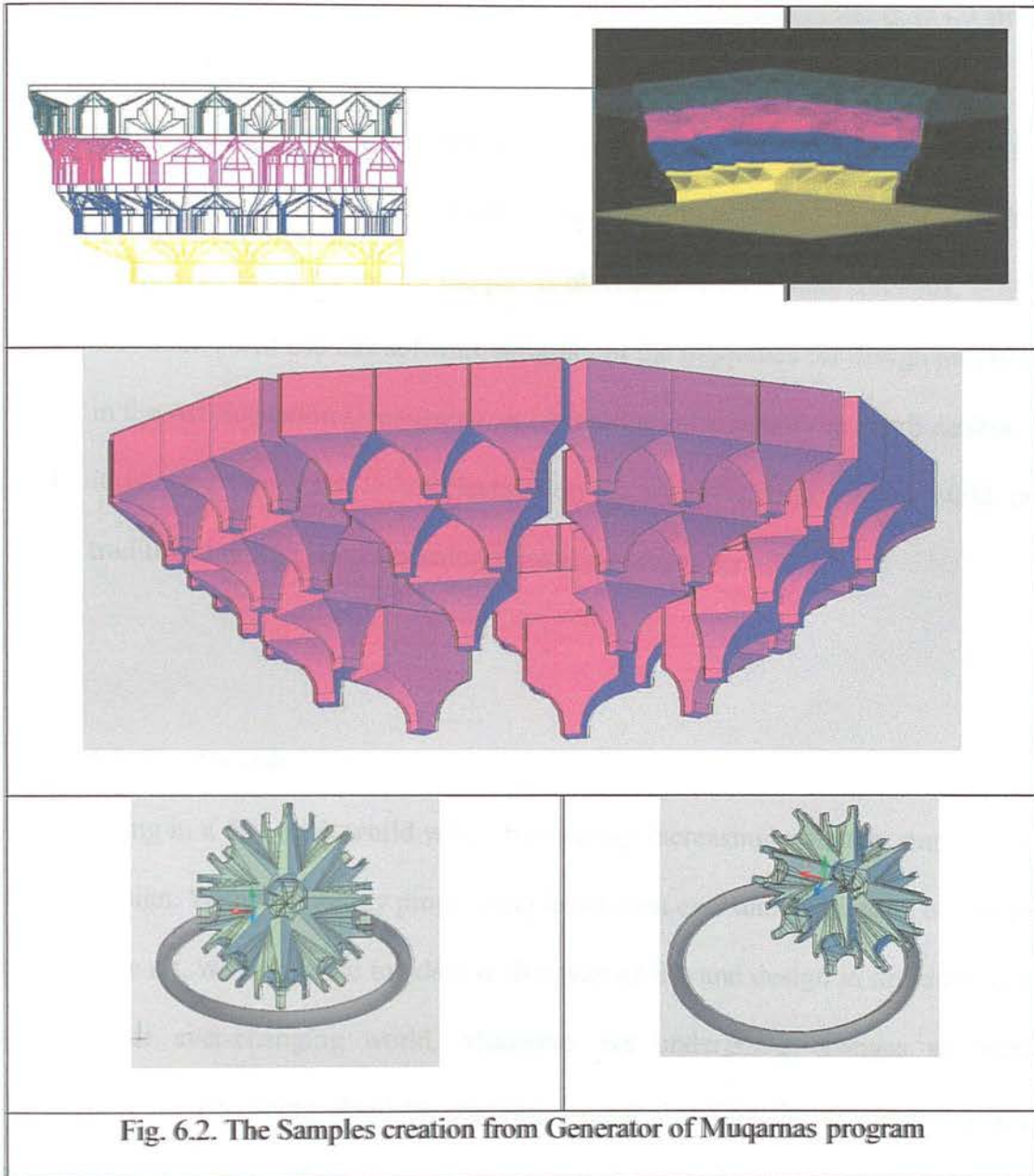
The present research suggests that a thorough study of the interpretation of the muqarnas should be conducted to produce a set of design criteria. These design criteria should characterise the muqarnas design as an innovative approach to allow the aesthetics of the muqarnas to fulfil this role successfully. It is also possible to making it integral to the design process within the new technologic forms.

The present research could benefit further designs for muqarnas in the future, in landscape, townscape, and interior design. The improved muqarnas could be used within some of the landscape or townscape street furniture, for example, on street lighting design, on the corners of buildings, pergolas, cantilever edges, lighting on the gardens and on the walls. Moreover, it could also be used for some of the elements of interior design, for example, in table structures, chandelier designs, and designs for wallpaper, doors, windows and jewellery decoration as shown in the following Fig. (6.2):









#### 6.4 Recommendations

The most important recommendations are:

1. The interest in analysing muqarnas from Islamic art puts artists and architects in the right position to recognise their tradition of Islamic architecture, which has been quite exclusive in favouring the internal aspects of buildings over the



external ones, and continues to do this in the present and is likely to do so in the future.

2. The value of providing a simple software program of the muqarnas allows for the development of new decorative designs and different modern building designs, by using the model 'muqarnas blocks' as ready-to-use elements.
3. The author will use this software program of the muqarnas for design purposes in the Art Education Department, in Unn al-Qura University in Saudi Arabia.
4. It is very important to use technology in creative ways and to build on traditional design elements using scientific technology.

#### **6.6. Final words**

We are living in a fast-track world where technology increasingly dictates our way of life and design. With technology progressing faster than ever and infiltrating our work and creative art, we are forced to adapt to this way of life and design in order to keep up with the ever-changing world. Muqarnas are undergoing changes as well. Decorations are becoming obsolete, creating a great strain on the muqarnas. In the long term, we need to allow the design of muqarnas to adapt and change with us. Otherwise, their inability to adapt and be flexible to our evolving needs will cause them to become obsolete.

This research has opened the gate to thinking about many of the ideas and concepts, to communicate with an authentic Islamic architecture's ornamentation history, and to be a witness in the history of Islamic art. In view of the fact that muqarnas are a living process, this involves growth and change with reference to art and design movements.

Producing a software version of the muqarnas is seen as deeply rooted, with its abstract, mathematical formation, which is more akin to contemporary computer art and various forms of experimental ornamentation art.

This study continues to be a bridge between the past, present and future, and a message of goodness of contemporary practitioners and viewers, by providing a simple software program for modelling the muqarnas. This program can be used to visualise data generated from the blocks of muqarnas, to create different options in the model (muqarnas blocks) that will allow them to assess alternative designs and have them ready for use in the form of computerised two-dimensional and three-dimensional drawings.

We are in need of flexible designs which not only facilitate us, but lay the foundation for new technology yet to materialise. Muqarnas are in demand for decorative designs that withstand a transformation. It is our duty to recognise usable decorations and their design contribution in order to increase their life and design span.

Through conducting the present research the author has himself gained a deeper understanding of mechanical functions in general and the design of muqarnas in particular. The author hopes this research will contribute to muqarnas as an aspect of creative character and how it should be dealt with in a new age of art. The author also hopes to use this experience to contribute to the future well-being of his own society and culture.

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i - One of the very few examples of non-Islamic muqarnas was commissioned by the Norman king Roger II, who in the mid-12<sup>th</sup> century ruled a Sicily only just conquered from the Muslims. His throne hall, now the Capella Palatina in Palermo, displays a splendid wooden muqarnas ceiling.

ii - Another example of non Arab-Islamic muqarnas can be found in Glamorgan in south Wales, UK, in the Arab Room in the Herbert Tower (1876–1886), in Cardiff Castle.

iii - The Prophet visited these seven heavens one by one and describes them in detail. Then he arrived near the Throne where there were eight Angels – eight rows of Angels – carrying the *Kursi* or the Seat of the Throne itself, above which God (Allah) Himself resides. (Ibn-Abbas n.d.:29)



## Bibliography

### A. English Books

The new Encyclopaedia Britannica, (1980), Volume 11, 15<sup>th</sup> Edition, Encyclopaedia Britannica Inc. Chicago. Available for purchase at Britannica's online store (britannicashop.britannica.co.uk) (2007).

Encyclopaedia Americana, (2006), Edition, Volume 30, New York.

- The American Heritage Dictionary, 2007, (American Heritage Dictionary of the English Language), Fourth Edition by Houghton Mifflin Company, New York.

Oxford English Dictionary, (2007), The Shorter Oxford English Dictionary, 6th edition. USA: Oxford University Press.

- James Stevens, (1999), Oxford Dictionary of Architecture, Oxford University Press.

Merriam-Webster's Collegiate Dictionary & Thesaurus, (2008) , Eleventh Edition and Collegiate Thesaurus Version 3.0. Available from: <http://www.merriam-webster.com/cgi-bin/book>. Accessed 24, April, 2009].

Abouseif, D. (1989) *Islamic Architecture in Cairo, An Introduction*. American University in Cairo Press. Cairo, Egypt.

Ardalan, N. and Bakhtiar, L. (1973) *The sense of unity*. University of Chicago Press. USA.

Aslanapa. O., (1971) *Turkish Art and Architecture*. London. UK.

Awad, M. (2000) *Islam and contemporary society*. London. Longman.

Al-Ghazālī, (1058–1111) *Mishkat al-anwar*, French tr. Rene Deladriere, Le tabernacle des lumieres (Paris, 1981).

Bacon, E. (1974) *The design of cities*. Thomason and Hudson Publisher, New York, Website, Available from: <www.state.me.us> [Accessed 6, August, 2008].

Balzer, W. and Moulines, C. (1996) *Structuralist theory of science*. Berlin: Gruyter.

Bertalanffy, L. (1952) *Problems of life: an evaluation of modern biological and scientific thought*. London: Watts

Bloom, J. M. (1988) *Muqarnas*. (ed) Graber O. An Annual of the Visual Culture of the Islamic World V.5. E.J. Brill Leiden. Netherland.

Boundon, R. (1971) *The uses of structuralism*. Translated by M. Vaughan, London.

Bradbury, W. (1981) *Into Unknown*. The Readers Digest Association, Inc. Pleasantville, New York, United States of America

Burckhard, T. (1976) *Language and Meaning of Islamic art*. First published. New York.

Capra, F. (1983) *The Tao of physics: an exploration of the parallels between modern physics and eastern mysticism*. Glasgow: William Collins.

Castera, J. M. (1999) *Arabesque*. tr. Kirk McElhearn, ACR Edition, Franc

Ching, Francis, D. K. (1995) *A Visual Dictionary of Architecture*. John Wiley & Sons, New York. USA.

- (1996) *Architecture: Form, Space, and Order*. John Wiley & Sons, Canada.

Creswell, K. A. C. (1940) *Early Islamic architecture* (E.M.A), Oxford University Press. UK.

- (1960) *The Muslim Architecture of Egypt* (E.M.A), Oxford University Press. UK.

- (1989) *A short Account of Early Muslim Architecture*. The American

University in Cairo Press. Cairo, Egypt.

De Saussure, F. (1966) *Course in General Linguistics*. London: McGraw-Hill.

Dalu, J. (1991) *The Element of Decoration: Surface Pattern and Light*. In Michel, G., (ed) *Architecture of the Islamic World*. P.144. Thames and Hudson Ltd, London.

Ecochard M. (1988) *Stereotomic de lieux portails du XII siecle* "notes" archeologie Musulmane Bulletin detudes Orientales de l'institut , Francais de Damas Vols 78.

Ehrmann, J. (1970) *Structuralism*. Garden City. NY: Anchor Books.

Emmerling, A. & Hildebrand, K. & Thürmer, G, 2003, " *A System for Modelling in Three-Dimensional Discrete Space*", Bauhaus-University Weimar, Germany Springer Berlin / Heidelberg

El-Said, I. (1976) *Geometric concepts in Islamic art*. London: World of Islamic Festival Publishing. London.

Frampton, K. (1992) *Modern Architecture: A Critical Hisrory*. London, Thames and Hudson

Gary, J. (1999) *Advance Waterfall Model*. Lab View Power programming. Paper book, Copyright (1998). The McGraw Hill Inc. New York. USA. Available from: <<http://www.dspace.fsktm.um.edu./Chapter3.pdf>> [Accessed 5, April, 2009].

Giddens, A. (1984) *Structuration theory: past, present and future*, in A. Giddens, *Theory of structuration: a critical appreciation*, London: Routledge.

Gonzalez, V. (2001) *Beauty and Islam: aesthetics in Islamic art and architecture*. London: I. B. Tauris.

Goodwin, G. (1991) *Turkey*. In Michel, G. (ed.) *Architecture of the Islamic World*. p. 220.

Thames and Hudson Ltd, London

Grabar, O. (1996) *Ornement, Formes et fonction dans Art Islamique*. Flammarion. Paris.

Grube, E. J. (1991) *What is Islamic Architecture*. In Michel, G. (ed.) *Architecture of the Islamic World*. Thames and Hudson Ltd, London.

Hamsen S. (2003), *Muqarnas Visualization in the Numerical Geometry Group*, Available from: <<http://www.iwr.uniheidelberg.de/groups/ngg/Muqarnas/index.php?L=E>> [Accessed 20, Jun, 2009].

Harris, C. M. (2005) *Dictionary Architecture and construction*. Fourth Edition, print by RR Donnelly, New York.

Herbert, D. and Thomas, C. (1997) *Cities in Space: city as place*. New York: Wiley.

Hertzberger, H. (1991) *Lessons for students in architecture*. Rotterdam: Uitgeverij Publishers

Heuvel, W. J. V. (1992) *Structuralism in Dutch architecture*. Rotterdam: Uitgeverij Publishers.

Hillier, B. and Hanson, J. (1990) *The Social Logic of Space*. Cambridge University Press.

Hoag, J. D. (1977) *Islamic Architecture*. Harry N. Abram, Inc. Publishers Electra/Rizzoli, New York. USA.

Hoadley, R. Bruce (2000), *"Understanding Wood: A Craftsman's Guide to Wood Technology* (2nd. ed.) Taunton Press.

Hume, D. (1967) *Treatise of human nature*. Oxford: Clarendon Press.

Hutt, A. (1991) *Iran*. In Michel, G. (ed.) *Architecture of the Islamic World*. p. 253. Thames and Hudson Ltd, London.

Jairazbhoy, R. A. (1962) *The Histoery of the Shrines at Mecca and Medina*. Islamic Review,

Asia Publishing House, London.

Janson, H. W. (1977) *A history of Art*. New Edition. First published by Thames and Hudson Ltd. London.

Jungblut, D. (2005) *Muqarnas Plan Editor*, Available from: <<http://pille.iwr.uni-heidelberg.de/~muqtool/#general#general>> [Accessed 28, May, 2009].

Krier L., 1984, " *Architectural Design*", Houses, Palaces, Cities, volume 54, Demetrio Porphyries', editor, Academy Publications, London,

Lang, J. (1988) "Symbolic aesthetics in architecture: toward a research agenda", in Nasr, Jack L., *Environmental aesthetics*, New York: Cambridge University Press.

Lewcock, R. (1991) *Materials and Techniques*. In Michel, G. (ed.) *Architecture of the Islamic World*. P.1140- 141. Thames and Hudson Ltd, London.

Linton, R. (1945) *The cultural background of personality*. New York, London: Appleton-Century.

Luchinger, A. (1981) *Structuralism in Architecture and Urban Planning*. Stuttgart: Karl Kramer Verlag.

Mann, A. T. (1993) *Sacred Architecture*. Great Britain: Element Books.

Mathews, F. (1994) *The ecological self*. London: Routledge.

Maurice G. D. (1949) *Ibn Jubayr, Rihlat (Voyage)*. Trans. Paris.

Mukarovsky, J. (1978) *Structure, sign and function*". New Haven: Yale University Press.

Nasr, S. H. (1971) "Sacred art in Persian culture", Middle East Forum,

- Newman, O. (1961) *Documents of modern architecture*. Vol. 1, Tirant
- (2008) *Art of Islamic language and meaning*, Titus Burckhardt Printed in China.
- Paccar, A. (1981) *Tradional Islamic Craft in Moroccan Arch*. Atiee, France.
- Parsons, T. (1951) *The System of Modern Societies*. Englewood Cliffs, N. J.: Prentice Hall.
- Philon H. (1991), *Iraq*. In Michel, G. (ed.) *Architecture of the Islamic World*. Thames and Hudson Ltd, London.
- Piaget, J. and Maschler, C. (1971) *Structuralism* [Structuralism – English] London: Routledge and Kegan Paul, the Gresham Press.
- Piaget, J. (1972) *Psychology and Epistemology: Towards a Theory of Knowledge*. Harmondsworth: Penguin.
- Pickthall, M. (1927) *Islamic Culture*. Lahore Pakistan: Ferozsons.
- Osborne, H. (1997) *The Oxford Companion to Art*. Published by Book Club Associates. Oxford University Press, UK.
- Rapoport, A. (1981) *Identity and environment: a cross cultural perspective*. in J.S. Duncan (ed.), London: Croom-Helm.
- Rivoira, (G.T), (1938) *Muslim Architecture, its Origins and Development*. (Translated from the Italian to English by G. Rushforth), London.
- Rosintal, (1928) *Trompes et Stalactites Dans L'architecture Orientale*. vol.1 in fold, Paris.
- Sabra, A. (1989) *The Optics of Ibn al-Hytham*. The first three volumes of this seven-volume treatise were translated with commentary. Vols. 1- 3. On Direct Vision, 2 vols. London.
- Santayana, G. (1986) *The sense of beauty*. New York: Dover Press.



Sims, E. (1991) *Market and Caravanserais*. In Michel, G. (ed.) *Architecture of the Islamic World*. Thames and Hudson Ltd, London.

Scott G. R. (1951) *Design Fundamentals*. The McGraw-Hill Company Inc. New York. USA

Takahashi, S. (1973) *Muqarnas: A Three Dimensional Decoration of Islamic Architecture*. Available from: <<http://www.tamabi.ac.jp/idd/shiro/muqarnas/data>> [Accessed, 19, May 2006].

Ujam, F. (2006) *'Locus Architecture Outline'*, School of Architecture, Edinburgh College of Art.

- (2007), In an interview about a number of western philosophies, conducted for the purpose of the research.

Unsal, T. (1959) *Islamic Turkish Architecture in Seljuk and Ottoman Time*. Unknown Press. London.

Warren, J. (1991) *Syria, Jordan and Lebanon*, In Michel, G. (ed.) *Architecture of the Islamic World*. Thames and Hudson Ltd, London.

Wilbrun D. (1955) *The Architecture of Islamic Iran: The Khanid period*. Princeton University Press, New Jersey, New York.

Wolfgang, H. (1958), "*Antoine Desgodetz and the Academie Royale d'Architecture*", *The Art Bulletin*. Yale University Press, New Haven.

Yaghan, M. A. - (2001) *The Islamic architectural element Muqarnas*. Paperback, Vienna, Austria.

- (2002-5), A short on-line course on Muqarnas, Available from: <<http://www.muqarnas.org/>> [Accessed 20, March, 2006].

## **B. Journal Articles**

- Assiter, A. (1984) Multiuser and structuralism. *British Journal of Sociology*, Vol. 33, pp.1–2.
- Eiseman, P. (1994) From Deep Structure to Architecture in Structuralism and Deconstruction. Thomas Patent Western Washington University. *In Journal of Architectural*, volume 17 No2.
- El-Basha H. (1965) The Muqarnas A Genuine Characteristic of Islamic Art – Its early use and development in Doom. *In Journal Minbuar al-Islam*, v,1. Al-Naheda Press, Egypt.
- (1988) The Legacy of Islamic Art - The Muqarnas, Its Early use in Islamic Doorways and Towers. *In Journal Minbar Al-Islam*, v, 5. Al-Naheda Press, Egypt.
- Shafie, F. (1954) Characteristics of Wood in Decorative in Abbasid and Fatimid Styles. *In Journal of Faculty College*, 16 vols. Cairo University Press, Cairo, Egypt.
- Hazem, I. (1999) Planning standard of mosques. *Al-Benna Architectural Magazine*, Vol. 1, Issue 1.
- Hillier, B. and Leaman, A. (1973) Structure, system, transformation: sciences of organisation and sciences of the artificial. *In Journal Transactions of the Bartlett Society*, Vol. 9, pp.36–7.
- Hill, J.N. and Evans R.K. (1972) "A model for classification and typology". In D.L. Clarke (ed.) *Models in Archaeology*. London: Methuen. Website, available from < [http://: www.en.wiktionary.org/wiki/typology](http://www.en.wiktionary.org/wiki/typology) > [Accessed March 27, 2008]
- Patin, T. (1993) From deep structure to architecture in suspense: Peter Eisenman, structuralism and deconstruction. *In journal of Architecture Education*, Vol. 47, No. 2, pp 88–100.
- Shafie, F. (1954) Characteristics of wood in decorative in Abbasid and Fatimid styles. *In journal of Faculty college*, vol. 16, Cairo University press, Cairo, Egypt.

Tabbaa ,Y. (2002) The Muqarnas dome and Vaults of Cairo. *Bulletin Journal of the Research center in Egypt*, Cairo, Egypt.

### C. Web sites Resources

Alison, S. & John, S., 1978, Medieval Illumination, Glass and Sculpture in Minnesota Collections", Minneapolis: University of Minnesota Gallery. Website, available from: (<<http://www.pitt.edu/~medart/menuglossary/INDEX.HTM>>, [Accessed 25 February 2009]

Arch: Available from: <<http://www.archiseek.com/guides/glossary/a.html>> [ Accessed 25May, 2007].

Architecture/decorate, Available from: <<http://www.islamicart.com//main/architecture/decorate.html>> [Accessed 12, may, 2007].

AutoCAD: @book{middlebrook2004ad, title={{AutoCAD 2005 for dummies}}, author={Middlebrook, M.}, year={2004}, publisher={For Dummies}}  
<http://en.wikipedia.org/wiki/AutoCAD>

Aya Sofia, Available from :< <http://www.ce.cmu.edu/~petera/photos/turkey/AyaSofia.html>,> [Accessed 9, September, 2007].

Cosmology:

- Vincent, C. 1981, "*The View from Planet Earth: Man Looks at the Cosmos*", New York: William Morrow & Company, Inc., Website, available from <<http://www.en.wikipedia.org/wiki/Cosmology>>, [Accessed 10, October 2008]

Ctesiphon, Available from :< <http://www.wikipedia.org/wiki/Ctesiphon>> [Accessed 9,July, 2007].

Form: Available from:<<http://www.en.wiktionary.org/wiki/form>> [Accessed 7, July, 2008].

Foxpro [http://en.wikipedia.org/wiki/Visual\\_FoxPro](http://en.wikipedia.org/wiki/Visual_FoxPro)  
@book{granor2000moa, title={{Microsoft Office Automation with Visual FoxPro}}, author={Granor, T.E.}, year={2000}, publisher={Hentzenwerke Publishing}}

Glossary: Available from:<[http:// www.theapologiaproject.org/glossary.htm](http://www.theapologiaproject.org/glossary.htm)> [Accessed 20, July, 2008].

- Available from:<<http://www.katarxis-publications.com/katarxis02-1/id24.html>> [Accessed 20, July, 2008].

- Available from:<[http:// www.state.me.us](http://www.state.me.us)> [Accessed 6, August, 2008].

- Available from: <[www.islamicart.com/index.htm](http://www.islamicart.com/index.htm)> [Accessed 24, January, 2006].

- Available from: <<http://www.archiseek.com/guides/glossary/a.html>> [ Accessed 25May, 2007].

- Available from:< <http://www.katarxis-publications.com/katarxis02-1/id24.html>> [Accessed 20, July, 2008].

- Available from:< <http://www.nyc.gov/html/lpc/html/glossary/glossary.shtml>> [Accessed 2, July, 2009].

- Available from:<<http://www.islamic-art.org/Glossary/NewGlossary.asp?DisplayedChar=13>> [Accessed 1, Jun, 2009].

Muqarnas definition: Available from:<<http://www.encislam.brill.nl/data/EncIslam/so/sim-5460-html>> [Accessed 6. December, 2005].

- Available from: <<http://www.en.wikipedia.org/wiki/Muqarnas>> [Accessed 2. June, 2006].

Hierarchy: Available from:<[http:// en.wiktionary.org/wiki/hierarchy](http://en.wiktionary.org/wiki/hierarchy)> [ Accessed 7, July, 2008].

Honeycomb: Available from:<[http:// www.wikipedia.org/wiki/Honey\\_comb](http://www.wikipedia.org/wiki/Honey_comb)> [Accessed 8,February, 2007]

Interior-design: Available from: <[http:// www.dcrinteriors.com/interior-design-glossary](http://www.dcrinteriors.com/interior-design-glossary)> [Accessed 5, Augast, 2008].

Kjeilen, T. (1994), '*Looklex Encyclopadeia*', Website, available from <<http://www.lexicorient.com/minaret>> [Accessed 25 February 2008]

Lisp : @article{anderson1984lpl,title={ {Learning to program in LISP} },author={Anderson, J.R. and Farrell, R. and Sauers, R.}, journal={Cognitive

Science}, volume={8}, number={2}, pages={87--129}, year={1984}, publisher={Elsevier}}  
<http://en.wikipedia.org/wiki/Lisp>

Marble: Available from: <<http://www.en.wikipedia.org/wiki/Marble>> [Accessed 6, July, 2008].

Minaret: Available from :< <http://www.en.wikipedia.org/wiki/Minaret>> [Accessed 18, February, 2008].

-Available from :< <http://www.lexicorient.com/minaret.htm>> [Accessed, 21, February, 2008].

Mihrab: *Encyclopædia Britannica.*, Website, available from

<<http://www.britannica.com/EBchecked/topic/381937/mihrab>> [Accessed, 9, August, 2007]

- Available from :< <http://www.i-cias.com>> [Accessed, 13, August, 2007].

- Available from:<<http://www.scholar.lib.vt.edu/theses.pdf>> [Accessed, 9, August, 2007].

- Available from :< <http://www.islamic-art.org/Glossary>> [Accessed, 28, August, 2007].

Minbar: Available from :< <http://www.archnet.org/library>> [Accessed 5, March, 2008].

Pendentive,

Heinle & Schlaich 1996, "*Pendentive*" Website, available from ,

<<http://en.wikipedia.org/wiki/Pendentive>, [Accessed 3, May, 2007].

Ottoman Mosques: Available from :< <http://www.islamicarchitecture.org>> [Accessed, 2, July, 2007].

Oster, J. D. & Frenkel, H. 1980, "*The Chemistry of the Reclamation of Sodic Soils with Gypsum and Lime*", Website, available from  
<<http://soil.scijournals.org/cgi/content/abstract/44/1/41>>[Accessed February 27, 2008]

Round arch: Avaialable from: <<http://www.gutenberg.org>> [Accesses 6, May, 2007].

Qusayr Amra, Available from :< <http://www.discoverislamicart.org/images/sample.pdf>,> [Accessed, October, 2007].

Stalactites: Available from: <<http://www.wikipedia.org/wiki/Stalactites>> [Accessed 8, May, 2006].

Squinch,

- Aliparsa, 2007, available at:< <http://www.wikipedia.org/wiki/Squinch>>

[Accessed 1, May, 2006].

- Available from :< <http://www.pitt.edu/~medart/menuglossary/squinch.htm>, > [Accessed 3, May, 2006].

- Available from :< <http://www.archnet.org.com>,> [Accessed, May, 2007].

Spherical, Available from :< [http://www.wikipedia.org/wiki/Spherical\\_angle](http://www.wikipedia.org/wiki/Spherical_angle)> [Accessed 2, February, 2007].

- Available from :< <http://www.answers.com/spherical-angle>> [Accessed 1, May, 2007].

Space: Available from:<<http://www.state.me.us/space>> [Accessed 6, August, 2008].

Typology:

Comrie, B. (1989). "Language universals and linguistic typology: Syntax and morphology",

Oxford: Blackwell, 2nd edn Website, available from (<<http://www.theapologiaproject.org>>,

[Accessed February 27, 2008]

- Available from:< <http://www.en.wiktionary.org/wiki/typology>> [Accessed 7, 20, July, 2008].

VBA [http://en.wikipedia.org/wiki/Visual\\_Basic\\_for\\_Applications](http://en.wikipedia.org/wiki/Visual_Basic_for_Applications).

@book {cummings2001vd,title={{VBA for Dummies}},author={Cummings, S.},  
year={2001},publisher={John Wiley & Sons, Inc. New York, NY, USA}}



VBA [http://en.wikipedia.org/wiki/Visual\\_Basic\\_for\\_Applications](http://en.wikipedia.org/wiki/Visual_Basic_for_Applications)

@book{cummings2001vd,title={{VBA for Dummies}},author={Cummings, S.},  
year={2001},publisher={John Wiley & Sons, Inc. New York, NY, USA}}

Whole: in *The American Heritage® Dictionary of the English Language, Fourth Edition*.

Source location: Houghton Mifflin Company, 2004. Website [Internet], available from

<<http://dictionary.reference.com/browse/whole>> & Available from:<

<http://dictionary.reference.com>>. Accessed: 24 January 2010.

Wood: Available from:<<http://www.wikipedia.org/wiki/wood>> [Accessed 5, May, 2008].

#### **D. Unpublished Theses/ Dissertations**

Abdullah, M. A. (1998) *Environmental knowledge and city perception: with a focus on the energy link to environmental aesthetics*. Unpublished Ph.D. thesis, Edinburgh College of Art, Heriot-Watt University.

Emin, M. (1987) *Complex Structures of the Islamic architectural in Cairo*. Cairo, Egypt, Cairo University, Department of Architecture, (unpublished PhD Dissertation).

Hamidi, M. (2003) *The city main structure's important in urban life and transformation*. Ph.D thesis, Edinburgh College of Art, Heriot-Watt University.

Islami, S. G. R. (1998) *Endogenous development: a model for the process of man-environment transaction*, unpublished Ph.D. thesis, Heriot-Watt University.

Kaki, W. A. (2000) *The structural approach to city image, Madinah al-Munawarah*, unpublished Ph.D. dissertation, Edinburgh College of Art, Heriot-Watt University, Department of Architecture.

Karim, F. S. (1987) *Mosques princes Sultan Al-Nasser Mohamed Bin Qlaon*. Cairo, Egypt,

Cairo University, Department of Architecture, (unpublished PhD Dissertation).

Masaud, A. (1996) *Adaptation and motivation: an environmental model for architecture meaning*, unpublished Ph.D. thesis, Heriot-Watt University.

Nabih, W. (1998) *System, control and sustainability*, unpublished Ph.D. thesis, Heriot-Watt University.

Shahata, A. and Foda, A., (2004), The Draft Three-Dimensional Model of the Holy Mosque, the Institute of Hajj Research, in Umm al-Qura University, Urban and Engineering Research, in Makkah. Research No: 42402001.

## **E. Arabic bibliography**

### **1. English Translation:**

Abdulhameed, M. (1948) *Wafiat Al-ay-an & Abna-Al-zaman*. V.5, Dar Alsade Press. Cairo. Egypt.

Abu Rayhan Al-Biruni, (1973) *E S Kennedy (973-1048)*. A commentary upon Biruni's '*Kitab, 'Tahdid al-Amakin'*'. An 11th century treatise on mathematical geography. Beirut. Lebanon.

Al-Any, A. (1983) *The scenes of the cone domes in Iraq*. First press, Iraq.

Abdulmoaty, F. (2007) *The history of the Kaabba and the in sanctuary Mosque*. First printing, Dar al-Forqan Press, Jeddah, Saudi Arabia.

Abdulwahab, H. (1946) *The antiquity mosque history*. Cairo University Press. Cairo, Egypt.

Atlasa, M. A. (1956) *Islamic antiquitea and history in Aleppo*. Ester Press Damascus, Syria.

Abulgawad, T. A. (1970) *Architecture history*. Dar Wahdan Press, Cairo, Egypt.

Alwaly, T. (1988) *The Islamic Mosque*. First pres, Dar al-Elm, Beirut, Lebanon.

- El-Bash, H. (1988) *Discussion in Islamic architecture and art*. Al-Nahda press, Cairo, Egypt.
- Fikry A. (1936) *Mosques of Kairouan*. Dar al-Mar-if, Cairo, Egypt.
- Haroon, A. (1960) *Al-Wasset Encyclopaedia*. third edition, Egypt.
- Hamouda, O. Y. (1990) *Theory and aesthetic values of architecture*, second edition, Dar al-Ma'arf press, Alexandria, Egypt
- Ghalib, A. (1988) *Encyclopaedia of Islamic Architecture*. First polisher. Dar al-Alim Press. Beirut, Lebanon.
- Ibn Sīnā (1985) *Kitab al-naja*. (ed). Majid Fakhri, Beirut, Lebanon.
- Khīar al-Dīn al-Zrkāly, (1957) *The quotations are taken from Rasā'il*. 5 vols. a version edited by, (rd) Egypt, in 1928. Dar Beirut Press. Beirut,. Lebanon
- Mar'awq, M. A. (1974) *Islamic ornamental arts in Morocco and Andalusia*. Beirut, Lebanon.
- Najati, M. (1980) *Perception on the eye of Ibn Sinna Apsychological Research for Arabs* Dar Al-Sharooq Press. Cairo, Egypt
- Nasr, S. H. (1967) *Islamic studies: essays on law, society, the sciences, and philosophy and sufism*. Beirut, Lebanon: Librairies Du Liban.
- Nasser, Hussien, (1948), '*Ibn Jubayr's Rihla (trips)*', Dar press, Egypt.
- Nazif, A. S. (1989) *Architectural studies*. Egyptian General Assembly Books Press, Cairo, Egypt,
- Mahmoud, U. Y. (1987) *Architectural between Indigenization and contemporary*. First edition, the professional printing and publishing Press, Alexandria, Egypt.

Marzoq, M. A. (1974) *Islamic ornament art in the Ottoman period*. Egyptian Plenary Session Press, Cairo, Egypt,

Maher, S. (1985) *Early period of Islamic Architecture*. Dar al-Marifah. Cairo, Egypt.

Kamel, H. (1994) *Islamic Architecture – Characteristics Details of Muqarnas*. Dar al-Fiker of Lebanese, Beirut.

Lamie, S. M, (1984) *Islamic Architectural legacy in Egypt*. First publisher, Dar al-Nahdah Press, Cairo, Egypt.

Okasha S. (1985) *The aesthetic values of Islamic architecture*. Dar al-Ma'arf Press, Cairo, Egypt.

Rihawey, A. (1990) *Islamic architecture culture*. King Abbdul Aziz University Press, Jeddah, Saudi Arabia.

Sameh, K. E. (1970) *Islamic Architecture in Egypt*. Cairo University Press, Cairo. Egypt.

Shafi, F., (1970) *Studies in Islamic Art and Architecture*. University of Cairo Press, Cairo, Egypt.

- (1977) *Islamic architecture past, present and future*. Cairo University press, Cairo, Egypt.

Salim, S. A. (1987) *Minarets of Egypt*. Youth University Institution press, Egypt.

Wali, T. (1995) *Development theory in Ibn Khldon's examples*. Manama, Bahrain: Bait al-Quran press.

## 2. Original Arabic sources:

القران الكريم. مصحف المدنية النبوية، مجمع الملك فهد لطباعة المصحف الشريف. المدينة المنورة، المملكة العربية السعودية.

أبو العباس شمس الدين أحمد بن محمد بن أبي بكر خلكان (١٩٤٨) وفيات الأعيان وأنباء الزمان. تحقيق محي الدين عبد الحميد، مطابع السادة، القاهرة، جمهورية مصر العربية.

أبو ریحان البیرونی (١٩٧٣) الکندی (٩٣٧- ١٠٤٨) تحديد الأماكن. بيروت، لبنان.

احمد فكري - (١٩٣٦) المسجد الجامع بالقیروان. دار المعارف، القاهرة، جمهورية مصر العربية.  
- (١٩٦٥) مساجد القاهرة ومدارسها. الجزء الأول العصر الفاطمي، دار المعارف، القاهرة.

ألفت يحي محمود (١٩٩٠) نظرية وقيم الجمال المعماري. الطبعة الثانية دار المعارف، الإسكندرية. جمهورية مصر العربية.

توفيق أحمد عبد الجواد (١٩٧٠) تاريخ العمارة. مجلد ٣، دار وهدان للطباعة والنشر، القاهرة، جمهورية مصر العربية.

ثروت عكاشة (١٩٨٥) القيم الجمالية في العمارة الإسلامية. دار المعارف، الإسكندرية. جمهورية مصر العربية.

حسن الباشا - (١٩٨٨) قاعة بحث في العمارة والفنون الإسلامية. دار النهضة العربية، القاهرة، جمهورية مصر العربية.  
- (١٩٧٩) مدخل إلى الآثار الإسلامية. دار النهضة العربية، القاهرة، جمهورية مصر العربية.

حسن عبد الوهاب (١٩٤٦) تاريخ المساجد الأثرية. طبعة جامعة القاهرة. القاهرة، جمهورية مصر العربية.

خير الدين الزكلي (١٩٢٨) رسائل أخوان الصفا وخلان الوفاء. الجزء الأول والثاني، والتي عنى بتصحيحه - الطباعة بدون، المطبعة العربية بمصر.

سعد ماهر (١٩٨٥) الفنون الإسلامية الزخرفية. دراسات في الحضارة الإسلامية، دار المعارف، جمهورية مصر العربية.

سيد عبد العزيز سالم (١٩٨٧) المآذن المصرية. مؤسسة شباب الجامعة للطباعة والنشر، القاهرة، جمهورية مصر العربية.

صالح لمعي مصطفى (١٩٨٤) التراث المعماري الإسلامي في مصر. دار النهضة، الطبعة الأولى، القاهرة، جمهورية مصر العربية.

طه الوالي (١٩٨٨) المساجد في الإسلام. الطبعة الأولى، دار العلم للملايين، بيروت، لبنان.

عبد الرحيم غالب (١٩٨٨) الموسوعة المعمارية الإسلامية. الطبعة الأولى، دار العلم للملايين، بيروت، لبنان.

عبد القادر الريحاوي (١٩٩٠) العمارة في الحضارة الإسلامية. طباعة جامعة الملك عبد العزيز، جدة، المملكة العربية السعودية.

علاء الدين أحمد العاني (١٩٨٣) المشاهد ذات القباب المخروطية في العراق. الطبعة الأولى، بدون، العراق.

عبد السلام أحمد نظيف (١٩٨٩) الدراسات في العمارة الإسلامية. الهيئة العامة للكتاب، جمهورية مصر العربية.

فريد شافعي - (١٩٧٠) العمارة العربية في مصر الإسلامية. المجلد الأول، طباعة جامعة القاهرة، القاهرة.

- (١٩٧٧) العمارة الإسلامية ماضيها وحاضرها ومستقبلها. طباعة جامعة القاهرة، القاهرة.

فتحي فواز عبد المعطي (٢٠٠٧) تاريخ الكعبة والمسجد الحرام. الطبعة الأولى، دار الفرقان للطباعة والتوزيع، جدة المملكة العربية السعودية.

كمال الدين سامح (١٩٧٠) العمارة الإسلامية في مصر. طباعة جامعة القاهرة، القاهرة، جمهورية مصر العربية.

محمد أسعد أطلس (١٩٥٦) الآثار الإسلامية والتاريخ في حلب. مطبعة الشرق بدمشق، سوريا.

محمد عبد العزيز مرزوق (١٩٧٤) الفنون الإسلامية في العصر العثماني. الهيئة المصرية العامة، جمهورية مصر العربية.



# APPENDIX

- Appendix on: Glossary of Terms
- Appendix two: The chronology of existing muqarnas
- Appendix three: Case study

# Appendix One

## Glossary of Terms

The definition of the words which the author used in this research are used from Islamic Art glossary (<<http://www.islamic-art.org/Glossary/NewGlossary.asp?DisplayedChar=13>>, 2008) and from another web resource (<<http://www.nyc.gov/html/lpc/html/glossary/glossary.shtml>, 2009), as follows:

### A

- Ablaq:** A decorative technique, popular during the Mamluk period, based on alternating courses of black and white masonry. The term is derived from the Turkish *iplik*, meaning rope or thread.
- Arabesque:** One of the main decorative elements in Islamic art. It is basically a scroll of leaf and stems where the intertwining elements create an interlacing geometric system. This vegetal scroll appears to whirl in circles and interlope with its own indefinite blossoms.
- Arch:** A curved structural member that spans an opening or recess and supports the weight of the structure above it. It is usually of a masonry construction, and used as a doorway, window, or a portal. Freestanding monumental arches have been built simply for symbolic purposes. Arches come in many different shapes, such as the flat arch, horseshoe arch, ogee arch, pointed arch, rounded arch, segmented arch, etc.
- Architectonic:** Architecture qualities observed in objects that are not typically architectural ones. Something having design characteristics relating to architecture.
- Arcade:** A series of opened or blind arches joined together by columns or piers.
- Apse:** Arch, vault, *is a semicircular recess covered with a hemispherical vault*, In architecture, the apse (Latin *absis* "arch, vault"; sometimes written *apsis*; plural *apses*) is a semicircular recess covered with a hemispherical vault.

### B

- Bab:** Gate or door.
- Bey:** Turkish for 'gentleman'. It is a general title of rank and is equivalent to the Arabic title *amir*.
- Bimaristan:** Derived from Persian, meaning 'place for the sick'. A general hospital. *Maristan* is alternative name for *bimaristan*.
- Bracket:** A projecting angled or curved form used as a support, found in conjunction with balconies, lintels, pediments, cornices, etc.
- Brick molding:** A milled wood trim piece covering the gap between the window frame and masonry, which can be rectilinear, curved or composite-curved.

## C

- Caliph:** Arabic for successor. The Qur'an (II: 30) describes Adam as the primordial norm and as Caliph, the representative of God on earth. Man in this sense is the vicegerent of God on earth.
- Cami:** A type of mosque. It is the modern Turkish spelling of the Arabic word *Jami*, Turkish word referring to a Friday or congregational mosque. The smaller mosque is referred to as *mescit*.
- Capital:** In architecture, a structural and decorative element that divides a column or pillar from the masonry that it supports. (From the Latin *capitellum*, "little head".)
- Caravanserai:** Derived from the Persian *karawan* (company of travellers) and *serai* (large inn). The caravanserai provided safe accommodation for travelling merchants and their goods. They functioned as centres of commerce and artisan manufacture, though not all buildings of this type and function were called caravanserai. Other terms describing the same building were *khan*, *wikala*, *funduk* or *ribat*. The use of multiple terms was a mere reflection of regional differences.
- Cell:** Any small compartment; "the cells of a honeycomb."
- Column:** An upright cylindrical support, usually structural and often also decorative. Columns usually consist of a base at the bottom, a round shaft tapering toward the top, and a capital. The capital may consist of several designs of muqarnas. A half-column is attached to a wall and does not bear weight.
- Corbel:** A supportive architectural bracket or block that projects from a wall, and which sometimes supports (or appears to support) a structural member such as a shaft.
- Cornice:** In architecture, it is the projecting upper section of an entablature. Also a term for any crowning projecting moulding that runs around the top of a building or the wall of a room.
- Cupola:** A small dome on a base crowning a roof.

## D

- Dar:** A place where a lot of movement takes place. The word *dar* is used for a wide variety of buildings; however the most common usage of the term is to mean a house.
- Dome:** In architecture, a hemispherical vault or ceiling over a circular opening. The dome is elevated further by being placed on a circular or polygonal base, called a *drum*.
- Diwan:** Arabic script, primarily used in the administrative documents of the Ottoman Sultan's chancery
- Drum:** A cylindrical or polygonal wall which supports a dome. Also called a tambour. Also used to describe the cylindrical sections of stone that make up the shaft of a column.

## E

- Elevation:** In architecture, this is an alternative word for façade: the vertical organisation of the face of

a building. Also, an architectural drawing in the form of a geometric projection of a building on a vertical plane, showing any one side, exterior or interior, of that building.

**Extrados:** The upper and / or outer vertical surfaces of arches and vaults. Also see: *intrados*.

## F

**Façade:** The front of a building, and any other sides of a building when they are emphasised architecturally. A façade usually accentuates the entrance to a building and prepares the visitor for the architectural style to be found inside.

**Finial:** A ornamental part usually placed at the top of an architectural structure such as a minaret or canopy. It can also refer to an ornamental piece ending at the top of a post or a piece of furniture.

**Floor Plan/ Ground Plan:** In architecture, a schematic representation of a building comprising a horizontal cross-section of the building as it would look at ground level. A ground plan shows the basic shape of a building and, usually, the outlines of other interior and exterior features.

**Flute / Fluted / Fluting:** Grooves or channels which are roughly semi-circular in cross-section. They are found repeated vertically in columns and pilasters, and are also used in frames and other mouldings.

**Frieze:** This is a continuous, decorative, horizontal band usually placed along the upper parts of a wall. Used to decorate the interior or exterior of a building. In classical architecture it was the part of the entablature between the architrave and the cornice. From the Latin *frisium* "fringe".

## G

**Geometric:** Any shape or form that has a more mathematical than organic design. Geometric designs are typically made with straight lines, or geometric shapes including circles, ovals, triangles, rectangles, squares, pentagons, hexagons, etc. Examples of geometric forms include spheres, cones, cylinders, tetrahedrons, pyramids, cubes and other polyhedrons.

**Grid:** A framework or pattern of horizontal and vertical parallel lines that usually cross at right angles to each other. When applied to street layouts this is called a grid-plan.

**Groin vault:** A vault formed by the intersection at right angles of two barrel vaults. Sometimes the arches of groin vaults may be pointed instead of round. Also see: *barrel vault*

## H

**Hamam:** A public bathhouse. It usually takes the form of a central, domed, hot room surrounded by smaller domed rooms. There will also be ancillary rooms, including a disrobing room and a cool room.

**Han:** An alternative word for a caravansaray, used particularly in Turkey. In an urban context, it can also refer to a structure for shops, warehousing, or various kinds of manufacturing.

**Hooded Moulding:** A projecting moulding on the wall above an arch.

**Horseshoe Arch:** An arch shaped like a horseshoe. Although seen to be associated with Islamic architecture, this form of arch actually predates it. Horseshoe arches are common in Armenian churches that predate the Arab conquests.

## I

**Icon:** This is a panel with a painting, usually in tempera, of Christ, the Virgin Mary, or another religious subject.

**Iconography:** In Art terminology, iconography is the pictorial representation of a subject, or the collected images illustrating a subject.

**Imam:** A religious leader; the preacher of the Friday ceremony or leader of the Muslim community.

**Intrados:** The underside of an arch or a vault. Also see: *extrados*.

**Iwan:** A vaulted open hall with a rectangular or arched facade. The *iwan* is a Persian invention and its origins can be traced back to the palaces of Achaemenid Iran. The *iwan* worked well as an entrance of a mosque, an entrance to the prayer hall or the prayer hall itself. The combination of four *iwans* arranged axially around a courtyard became one of the most important plans of religious buildings in the Muslim world. The *qibla iwan* (sanctuary *iwan*) was always the largest and the deepest. The opposite one was next in size and the other two were the smallest.

**Izar:** A decorative frieze.

## J

**Jami:** From the Arabic root *jam'*, which means to 'gather things' and literally means mosque. This is why it is used to denote the mosque where the Friday noon prayer is celebrated. It is the principal religious building of Islam. The simplest and earliest form it took was the *riwaq*-mosque; opened arcades overlooking a squarish or rectangular open courtyard.

## K

**Ka'ba:** The house of God which is located in Mecca. Muslims face the Ka'ba when they pray and this is the direction to which *mihrabs* point. It was Ibrahim (Abraham) and his son Isma'il who rebuilt the Ka'ba as ordered by God. The Qur'an tells us that God ordered Ibrahim to build a sanctuary at a specific spot in Bacca (XXII:26), another name for Mecca. Ibrahim and Isma'il were told that it should be a cube and around a celestial stone, which was preserved nearby a hill in Mecca and then given to Ibrahim by an Angel. This black stone was kept at the eastern corner of the Ka'ba. God then informed Ibrahim to institute the rite of pilgrimage to Mecca.

**Kale:** This is the Turkish word for castle, e.g.: "Kars Kalesi" which means Kars castle.

**Keystone:** The central wedge-shaped member of a masonry arch; also used as a decorative element on arches in wood structures.

**Kufic:** One of the oldest types of Arabic calligraphy and the first calligraphic perfection of Islam. Its name derives from the Iraqi town Kufa, which was one of the earliest centers of Islamic

learning. Kufic has many derivatives; *al-kufi al-farisi* or *al-kufi al-baghdadi* and *al-kufi al-maghribi*. It is also the direct ancestor of all the calligraphic styles of Andalusia and of North-West Africa.

## L

**Lintel:** The horizontal stone or beam over an opening. This is usually found above doors and windows and was often decorated.

## M

**Masjid:** Mosque.

**Malwiya:** A spiral tower.

**Molding:** A decorative band of varied contour, used to trim structural members, wall planes, and openings.

**Medrese:** An institute for higher education, in which religious sciences were taught. The *madrasa* usually consisted of the teaching halls and the dorms. Most have a monumental entrance flanked with one or two minarets.

**Mihrab:** A prayer niche found in religious buildings indicating the direction to the Ka'ba in Mecca. The *mihrab* can be either flat or a concave recess in the wall; the latter form is the most popular one. Most *mihrabs* were decorated with stucco carvings, marble dadoes or mosaic. These *mihrabs* were wooden, intricately decorated and can be moved from one place to the other.

**Minaret:** In Islamic architecture, this is a tall tower that is attached to or built next to a mosque. At the top of every minaret is a balcony from which the muezzin (a Muslim crier) calls the faithful to prayer five times a day. The Arabic form of the word is *manarah*, meaning "place of light". Most minarets in Anatolia are cylindrical in nature and have spiral staircases inside.

**Minber:** Pulpit from which the *imam* of the mosque gives his sermon on Friday. Intricate geometric patterns with mother of pearl inlay and ivory usually adorned *minbars*. Wood was the most common material used for the construction of *minbars*, however stone and marble were used as well.

**Module:** A module is the basic unit of which the dimensions of the major parts of a work are multiples. The principle is used in sculpture and other art forms, but it is often most employed in architecture, where the module may be the dimensions of an important part of a building, such as a column, or simply some commonly accepted unit of measurement.

**Mosque:** An Islamic place of worship. "Mosque" is a French word derived from the Arabic word "masjid", meaning a place of prostration. The term "masjid" ("mescit" in Turkish) refers to mosques that could be used every day. The covered part of a mosque is called the prayer hall, most mosques also have an outer courtyard. Also see: *medrese*, *mihrab*, *minaret*, *mimber*.



<b>Mosaic:</b>	A design made of tiny pieces (called tessera) of coloured stone, glass, or tile set into a surface of plaster or concrete. It is used to decorate walls, ceilings, vaults, or floors.
<b>Motif:</b>	A consistent or recurrent element. In an architectural or decorative pattern, a motif is either employed as the central element in a work, or it is repeated either consistently or as a theme with variations.
<b>N</b>	
<b>Necking:</b>	A narrow moulding at the bottom of a capital that masks the junction between the capital and the shaft of the column.
<b>Niche:</b>	Any recess within the thickness of a wall.
<b>O</b>	
<b>Ornament:</b>	Is a form of surface decoration; something that decorates, adorns, or embellishes. Ornamentation is the class of things that are ornamental.
<b>P</b>	
<b>Panel:</b>	A portion of a flat surface recessed, or raised from the surrounding area, distinctly set off by molding or some other decorative device.
<b>Pendentive:</b>	A concave, triangular piece of masonry placed at the corners of a square bay and used to make a structural and visual transition from the square bay to the circular base of a covering drum or dome. It is actually, a triangular section of a hemisphere. Contrast with: <i>squinch</i> .
<b>Pilaster:</b>	In architecture, a flat, rectangular column (sometimes fluted) with a capital and base, that is attached to or set into a wall and which projects only slightly from that wall. It may be used decoratively as an ornamental motif, or used to buttress the wall. Contrast it with: <i>column</i> , <i>pier</i> .
<b>Pier:</b>	1. A column designed to support concentrated load. 2. A member, usually in the form of a thickened section, which forms an integral part of a wall; usually placed at intervals along the wall to provide lateral support or to take concentrated vertical loads.
<b>pointing, repointing:</b>	The treatment of joints between bricks, stone, or other masonry components by filling with mortar; also, called tuck-pointing.
<b>Plan:</b>	The horizontal arrangement of a building. Also, a drawing, diagram, or map of this arrangement, shown as if seen from above.
<b>Pointed Vault:</b>	A vault with a cross section resembling a pointed arch. Contrast with: <i>barrel vault</i> .
<b>Portal:</b>	A doorway or entrance, especially one that is large and imposing.
<b>Q</b>	
<b>Qal'a:</b>	A citadel.
<b>Qandil:</b>	Lamp.
<b>Qasr:</b>	Palace.
<b>Qaysariyya:</b>	A type of caravanserai that lodges craftsmen on its upper floors and housed their goods on

the ground floor around a *sahn*.

**Qibla:** The direction to Ka'ba in Mecca. For example, the *mihrab* is found in the *qibla* wall of a mosque.

**Qubba:** Literally means dome. It is also used to mean a mausoleum.

**Qur'an** The Word of God revealed to the Prophet Muhammad.

## R

**Rawshan:** Another term for *mashrabiyyas*. More specifically, it is used to describe *mashrabiyyas* when they overlook a street, forming some sort of balcony.

**Recess:** A small concavity.

**Reveal:** The side of an opening for a door or window between the frame and the outer surface of a wall, showing the wall's thickness.

**Rib:** A slender arch of masonry, often moulded, that projects from the under surface of a vault. It forms part of the framework on which the vault rests.

**Rise:** The vertical distance between the spring line of an arch or vault and the keystone or boss.

**Riwaq:** The meaning of this word differs according to the context in which it was used. In a mosque, it means an arcade carried on columns or pillars. In a house, it means a living unit with all its dependencies.

**Row:** An arrangement of objects or people side by side in a line; "a row of chairs

**Round arch:** A semicircular arch.

**Rustication,** Stonework composed of large blocks of masonry separated by wide, recessed joints; often

**Rusticated:** imitated in other materials for decorative purposes

## S

**Sabil:** Drinking fountain usually established for public charity.

**Salamilk:** Men's reception area in houses and palaces. During the nineteenth century A.D. rich households had the *salamlik* as a separate building.

**Sawma'a** Cell or minaret.

**Semi-Dome:** A half dome. Compare with dome.

**Shaft** In architecture, the shaft is the part of a column between the capital and the base. It may be monolithic, or constructed out of several cylindrical elements called drums.

**shouldered arc:** An arch composed of a square-headed lintel supported at each end by a concave corbel

**Span:** The horizontal distance between the two supporting members of an arch or vault.

**Sidelight:** A vertically framed area of fixed glass, often subdivided into panes, flanking a door.

**Spiral**

<b>Springing Arch</b>	In architecture, this is the lowest voussoir of an arch. The point where the vertical support for an arch (or vault) terminates and the curve of the arch (or vault) begins is called the spring line.
<b>Squinches</b>	An arch or system of arches usually placed at the corners of a square supporting a dome. Contrast it with <u>a pendentive</u> .
<b>Stucco:</b>	A coating for exterior walls made from Portland cement, lime, sand, and water.
<b>Sura:</b>	Qur'an chapter.
<b>T</b>	
<b>Tabaqa:</b>	The Arabic root means 'to fold' and also means 'level; levels of earth, buildings or people'. In architecture it means a lodging area in a building; a room, a duplex, triplex, etc.
<b>Taj al-Amud</b>	Capital of a column. Different capitals were used in Muslim architecture, amongst which are the ionic, Corinthian, <i>muqarnas</i> and bell-shaped capitals.
<b>Taq :</b>	Persian for arch.
<b>Transition Zone:</b>	A supporting arch that runs across a vault from side to side usually structural, but sometimes purely decorative.
<b>V</b>	
<b>Volute:</b>	A carved spiral form in classical architecture; often used in pairs as in the capitals of Ionic columns.
<b>W</b>	
<b>Wali:</b>	Governor.
<b>Wikala:</b>	The Egyptian caravanserai. Like the khan, the basic plan consisted of an open court surrounded by rooms for storing merchants' goods and for their display as well. Annexed there is usually an area that would function as a stable for housing the animals of the merchants, mostly horses. The upper floors of a khan are the accommodation areas, with single rooms, duplexes or triplexes for the travelers.
<b>Z</b>	
<b>Zawiya:</b>	In Arabic, it literally means collecting things and then compressing them or contracting them. It can also mean a corner. <i>Zawiyas</i> were also used by Sufi <i>tariqas</i> and named after them and in this sense resemble <i>khanqas</i> . <i>Zawiyas</i> however had no lodging area.
<b>Zellij</b>	Moroccan Arabic term for small enamelled ceramic tiles used to decorate buildings. These are used extensively in North African and Andalusian architecture.
<b>Zigzag decoration:</b>	A decorative motif (pattern) resembling inverted V, similar to the stripes worn.

## Appendix two

### The chronology table of existing muqarnas

Architecture, Art and Social/ Cultural Dimension	Period	Geometry, Function and Technology
Transform the Muqarnas to new age use without losing its meaning, and to see its application more appealing to the contemporary profession and students.	New Age 2000 +	Development of muqarnas by its integration into software and by a computer generated model to assist use in new age design and art. Will find alternatives muqarnas block ready for use, and putting into technical effect. Multi division created technology can be seen clearly in the muqarnas vaults.
Reproduces the traditional muqarnas as practiced by later exponents. Replaced by a culture of old impressions, eclectic manifestation, and a cultural heritage of the Middle East in different period and was mixed together with new features.	Post Modern 1980 +	Original contribution of the muqarnas variety of solutions, adherence to preserve rational, elitist and exhibitionistic designs with muqarnas forms creates a harmonious constitution in many works of art. Multi division created muqarnas from the old stylish creation.
Disappearance of muqarnas ideology of unadorned form follows function', purism in simplicity, machine aesthetic. Sculpture and art like 'crystal symbols of a new faith' and recreation legacy of intent regarding pressing contemporary building issues.	Modern Movement 1919 +	Geometric compositions of the muqarnas helped to enrich the geometric decoration, to emphasise key points of the design, or simply to fill the background or spaces by the geometric pattern, with the machine characterised by the 'Depreciation of material that results from the treatment by machine, and also, with existing industrial enterprises for mutual stimulation. The use of a plainer, a concave and a prismatic muqarnas.
The stability of Ottoman period includes an instructive range of examples by which the power of the sultan and of the Ottoman state was manifest in a visual form. Western influence in Ottoman land. For as long as people have held power, they have looked for ways in which to demonstrate it. The Westernised elements of buildings and palaces offered a magnificence and opulence cherished by the Ottoman sultans and kings.  The dome symbolises the eternal	Ottoman 16c – 20c	The use of the Muqarnas reached a very sophisticated level. It has been used in ingeniously subtle ways to communicate a sense of the powerful, by surrounding the viewer with an impressive array of exquisite ornament, creates an aesthetic ambience reflective of the power of the patron. The Muqarnas particularly known as a construction of going from a square form, nearly vertical, to a spherical form whose base is a circle. The use a concave and a stalactite muqarnas, in which the interlacing develops from a central star to occupy the entire area available. Ceilings

<p>universe and it has been interpreted as a representation of the vault of heaven.</p>		<p>were also embellished with geometric motifs, often multicoloured and gilded, which has been interpreted as a representation of the vault of heaven.</p>
<p>Anarchy and instability. Contemporary society was astonishingly heterogeneous ethnically, religiously and even linguistically. The Mamluks built an empire that excelled as one of the greatest powers of Islam. While Islam was the main religion of the empire, large Catholic and Orthodox Christian communities, particularly the Coptic Church in Egypt, contributed to its spiritual and cultural fabric, as did various Jewish groups.</p> <p>Artisans drew readily on the many influences available to them from the East and the West.</p>	<p>Mamluke 13c – 15c</p>	<p>Geometric decoration was combined particularly well with <i>kufic</i> script that afforded a certain aesthetic value. They used plainer and a prismatic muqarnas types, and also, used to enrich the geometric composition. For abstraction process to be seen in certain muqarnas with radial geometric decoration and to reach the simplicity of radial lines that form triangular sections. The Mamluks artists did not invent geometric decoration but they maintain it in full potential.</p>
<p>An integral part of Islamic civilisation, the Muslim West, has always retained its individuality, which is particularly evident in the architectural and decorative innovations taken from the Eastern tradition and developed in al-Andalusian and the Morocco to create an artistic style peculiar to this corner of the Muslim world. Today, the Muslim West displays its cultural heritage in the expressions of the muqarnas.</p> <p>The combination of Andalusian influences and the early appearance of what are clearly Eastern elements is evidence of the Maghreb's role as a bridge between East and West.</p>	<p>Andalusian 12c – 13c</p>	<p>The use of the muqarnas reached a very sophisticated level.</p> <p>The horseshoe arch was the most typical of the available decorative devices; craftsmen created new styles of arches and combined them in different ways. The same was true of capitals, with craftsmen changing the proportions and embellishing the muqarnas stalactite models to decorate interior spaces and building façades by the systematic use of the arch and the capital as decorative motifs at their own style.</p> <p>The use a concave, prismatic and stalactite types of muqarnas.</p>
<p>The power moved to Seljuk from sovereignty state and civilisations. Muslim artists did not 'invent' geometric decoration but they developed it to its full potential and developed an artistic style rooted in the heritage of the many civilisations of Asia and Anatolia, as result of Byzantine and Sassanian culture, thereby influencing architectural style.</p>	<p>Seljuk 11c – 14c</p>	<p>Architectural forms usually domical on square or polygonal plan and shaded colonnades. The muqarnas uses mainly tile, clay for bricks, rubble for stone, wood and plaster. Due to the desire to leave no spaces undecorated and to influence of Islam geometric decoration were preferred for the decoration of religious buildings. The designs were used in various ways across all the arts ranging from, tiles, ceramics, woodwork and stonework.</p>

# Appendix 3

# case study



- 1. **Introduction.....**
  
- 2. **Proportion order illustration of the Holy Mosque in Makkah**
  - 2.1. Arches theme .....
  - 2.2. Capitals theme .....
  - 2.3. Domes theme .....
  - 2.4. Minarets theme .....
  
- 3. **The identity of the muqarnas examples**
  - 3.1. Form .....
  - 3.2. Space .....
  - 3.3. Ornament .....
  - 3.4. Hierarchy .....
  - 3.5. Wholeness .....
  - 3.6. Unity .....
  - 3.7. Aesthetics and symbolism .....
  
- 4. **Conclusion of case study .....**

## 1. Introduction

The muqarnas legacy is a shining landmark of the creative achievements through which Islamic culture has contributed to the enrichment of Islamic art through different periods, as a result of its aesthetic and artistic aspects and its symbols. The muqarnas is a required feature in the ornament and architecture of the mosque, and can be used both as an architectonic form and as a decoration, and it has often been applied using different typology in different parts of the mosque. For this reason, the author has decided to focus on the great monument of *al-Masjid al-Haram* mosque (Holy Mosque) in Makkah. The author visited this site in January 2010 for the purpose of presenting this case study, which testifies to the genius of its architects and engineers, the perpetuity of its art and the deep-rootedness of its symbols and proportions, reflecting a wide range of different styles in terms of their relationship to the muqarnas.

In this case study the author will demonstrate the relevance of the themes that emerge in this thesis by illustrating the form, space, ornament, hierarchy, wholeness, unity, aesthetics and symbolism of the Holy Mosque in Makkah. The author has discussed the muqarnas in its rich spatial forms, and its ornamental format comprehensively in Chapter Three, with special emphasis on the arch, capital, dome, mihrab and minaret, and has analysed the mathematic, geometric and proportional aspects of its aesthetics. This case study gives the reader a better understanding from the point of view of the revitalisation of the concept of the muqarnas in contemporary architecture, particularly in the Holy Mosque or *al-Masjid al-Haram* mosque in Makkah. The author grew up in the holy city of Makkah, and it is this that triggered his interest in Islamic ornamental art in general and the muqarnas in particular.

Makkah is a city in Saudi Arabia, in the historic Hejaz region, the most sacred site in Islam, to which it is serving upon all Muslims, as they are able to make a pilgrimage there once in their

lifetime. It used to be a village, established by Prophet *Ibrahim* (Abraham), but the site was sacred before Islam, and was converted into a mosque with the Muslim conquest of Makkah, in AD 630, by the Prophet Muhammad (Peace Be Upon Him). With a population of 1.7 million (2008), the city is located 73 km (45 miles) inland from Jeddah in a narrow valley at a height of 277m (910ft) above sea level (Abdulmeaty, 2007, pp. 191-198).

The religious centre of the Holy City of Makkah is the Haram Mosque (*al-Masjid al-Haram*), Haram, meaning "sanctuary" (Oxford English Dictionary, 2008). *Al-Masjid al-Haram* mosque is 266,000m<sup>2</sup>, and the building consists of vast irregular colonnades surrounding an open courtyard, in the centre of which is the Ka'ba (a cube-shaped chamber measuring 13 m × 11 m, more than 16 m high) that all Muslims turn to in prayer five times each day. Within the courtyard is the Zamzam well, which sprang up miraculously for *Isham'il* and his mother. Converted into a mosque by the Prophet Muhammad (Peace Be Upon Him) in AD 630, the building was enlarged in the 7th century by caliph *Umar bin al-Khattab* and caliph *Uthman Ibn Affan*. The Umayyad caliph *al-Walid I* decorated it with wall mosaics in the 8th century. In the 9th century the Abbasid caliph *al-Mahdi* rebuilt the colonnades around the courtyard; but it was the Ottoman sultan, *Selim II*, who in the 16th century gave it the form of a central courtyard surrounded by stone walls (Fig. A.1), which stood until the recent rebuilding by the Saudi kings, in the 20th century, and further modification, rebuilding, and expansion work is going on to this day. It has 155 doors and 9 minarets (Fig. A.2).



Fig. A.1. The rebuilt *al-Masjid al-Haram* mosque, in the Ottoman sultanate, *Selim II*, in the 16th century



Fig. A.2. Rebuilding and layout of *al-Masjid al-Haram* mosque, by the Saudi kings, in the 21st century

As with any Islamic religious building, the architects and designers who were involved in the development of *al-Masjid al-Haram* mosque have given attention to the significance of the muqarnas as an ornamental way of expressing meaning and aesthetic quality, which creates decoration and beauty.

However, such explanations tend to overlook the fact that the muqarnas has a structural and ornamental function, The author has discussed in Chapter Two how it is found in arches, domes,

façades, capitals, windows, ceilings, mihrab and minarets, and where it has been applied using different materials such as stucco, stone and marble. The author will here illustrate these points in two sections, the proportion order and identity of the muqarnas through the important themes of structuring of the Holy Mosque of *al-Masjid al-Haram* in Makkah.

## 2. Proportion order illustration of the *al-Masjid al-Haram* Mosque in Makkah

The idea of proportion derives from that of ratio, which is "a system of relationships of parts to each other and to the whole" (Oxford Dictionary of Architecture, 1999, p.512). The subject of proportion has been discussed by the author in Chapter Three (pp. 130–139) as the relation of one part to the whole, or to other parts.

The concepts of 'symmetry' are based on harmonic proportions, the linear numerical methods of analysis of geometrically constructed designs invariably result in approximation or inaccuracies because of the irrational numbers derived from the proportions of the geometric elements of the design (Al-Bayruni, 1048, p.11).

There is another much more interesting set of numerical ratios of the muqarnas. It is used in setting out the perfect sequence of elements, developed in a proportionate series of whole integers, giving the harmonic progression of 1-1-2-3-5-8-13-21..., and so on, known as the summation series or the Fibonacci scale.

The particular property of this series is that it gives us the closest whole number approximation to mean and extreme ratios.

The interesting thing about such ratios is that they involve a definite rhythmic progression. The same relationship is repeated in each increase of magnitude. This is much richer in its possibilities than a simple numerical ratio. We can apply the idea in the same fashion as our 1:2 and 2:3 ratios to lines, areas, or any other commensurate element in the composition (Scott, 1951, p.55).

The Muslims used proportion in order to achieve the most beautiful and perfect ratios in their architectural works. These are considered to be 1:1, 1:1.5 – 1:1, 1:1/3 – 1:1, 1:1/4 – 1:1, 1:1/8. The aforementioned epistles of *Ikhwan al-Safa* discuss these proportions through the image and structure of the human body.



The finest manufactures and perfected composures and the best inventions which its structure and the formation of its parts are according to the ideal ratios; the ideal ratios are: one to one; one to one and half; one to one and one third; one to one and one quarter; one to one and one eighth (al-Zrkaly, 1928, p.183).

In order to achieve the main objective of Chapter Three of this thesis, in this examination of the proportions of the architectural elements of *al-Masjid al-Haram* mosque and their relations to the muqarnas from the point of view of their aesthetic significance, the author will focus on illustrating the following elements: arches, capitals, domes, and minarets.

### 2.1. Arches theme

The arch, known as an arch-ring, is set out in a curved form to span an opening and carry a superimposed load (Oxford Dictionary of Architecture, 1999, p.27). The muqarnas in arches has developed from an arch constructed as part of an ornamental arch and supporting structure. In this case study the author compares the round arch with the same construction of the unit arch of the muqarnas. The proportions of arches in *al-Masjid al-Haram* mosque are linked through the unit of the muqarnas. For example, in the measurements of the arches of the *al-Masjid al-Haram* mosque, the span between the two feet of the arch is 3.18 m, and the height is 9.5 m. These measurements were taken by the author, and are the same as those of Nazif (1989), when he describes the construction of *al-Masjid al-Haram* mosque (Fig. A.3). In order to get the relationships of arch to the height, the ratio of the arch of *al-Masjid al-Haram* mosque to the height =  $9.5 \div 3.18 = 2.987 = 3 \approx$

$\therefore$  The proportional ratio of this construction is = 1: 3



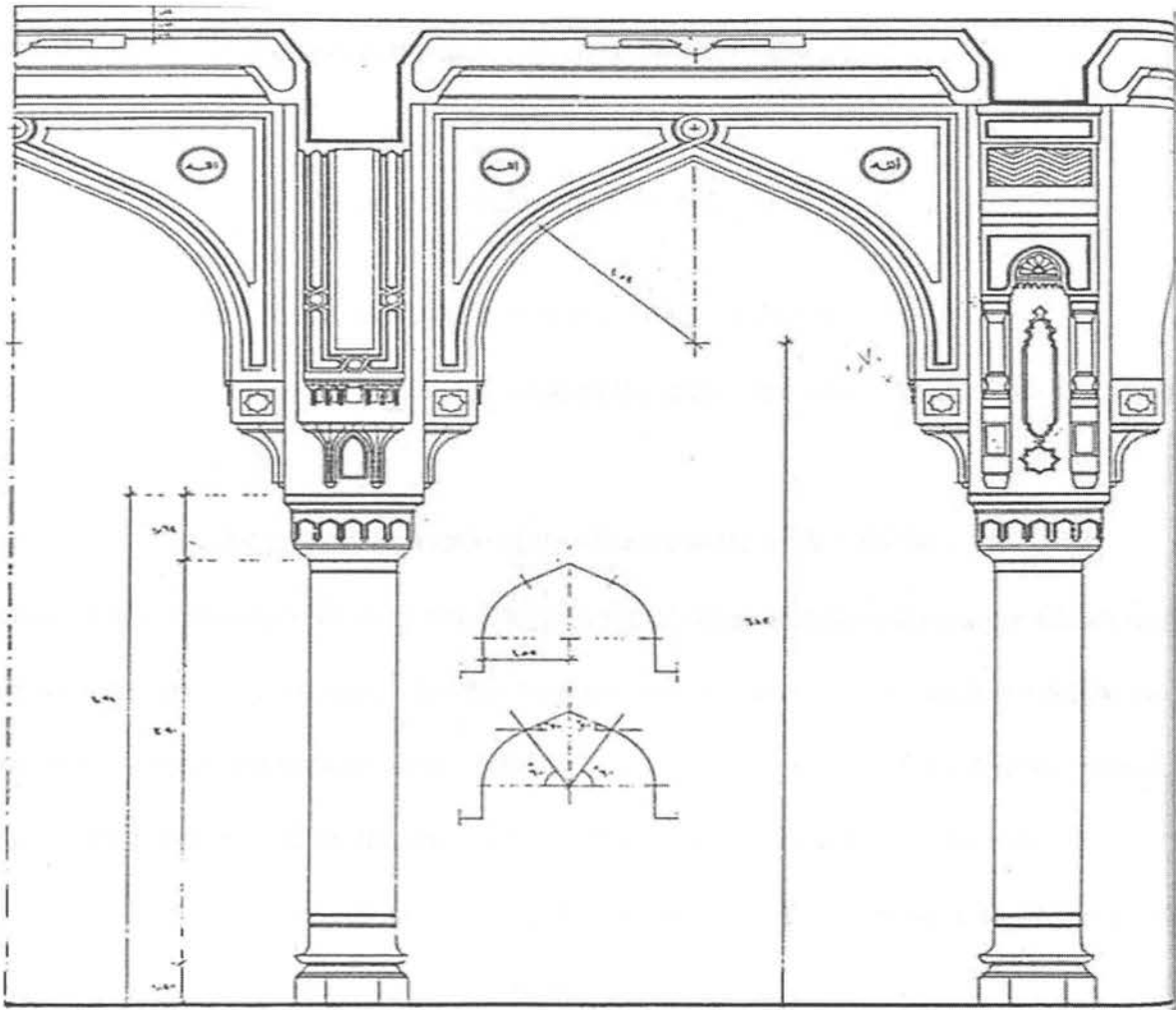


Fig. A.3. The measurements and section details of the whole arch include a column, with muqarnas support decorated and corbel, in *al-Masjid al-Haram* mosque, by Nazif (1989)

In the middle of the measurement illustration (Fig. A.3), the radius of the arch is 1.59 m, and the curving of the arch is 3.08 m. In order to determine the two curves of the arch, both curves have been identified on the straight horizontal of the centre, and then they continue upward towards the line within the limits of an angle of 60 degrees, and the curving is completed by extending two diagonal lines at an angle of 30 degrees. Until they meet up with the vertical axis, the two curves of the arches continue to go vertically, sloping from the central line of the span which is 0.7 m, whereas the dimension of the span between the centre and the curve of the arch is 1.59 m.

Therefore, the height of the total arch = the span of the curved arch from the centre + the span of the feet of the sliding arch =  $3.08 + 0.70 = 3.78$  m.

Therefore, the total proportion of the arch = the total altitude  $\div$  the length of the total arch =

$$= 3.78 \div 3.18 = 1.18 \text{ m.}$$

$\therefore$  The proportional ratio of the arch = 1:1.18  $\approx$  1:1

The span between the ground and height of the arch = 9.5 - 3.78 = 5.72 m.

Therefore, the proportional ratio of the altitude of the arch = the total altitude  $\div$  the altitude of the arch = 9.5  $\div$  5.72 = 1.66 m.

$\therefore$  The proportional ratio of the altitude to the arch = 1:1.66  $\approx$  1:2

Another simple calculation of the pointed arch in the *al-Masjid al-Haram* mosque allows us to get the ratio of the arch to its height. The span between the two centres of the arch is 1.88 m, the span between the centres and the curvature of the arch is 0.43 m, the height of the double-centred point of the pointed arch is 1.05 m, the span between the centre and the foot of the arch is 0.72 m, the length of the arch is 2.74 m and the total height of the arch is 1.77 m. These measurements and the photograph were taken by the author (Fig. A.4).

Therefore, the overall proportional ratio = length of the arch  $\div$  height of the arch

$$= 2.74 \div 1.77 = 1.548 \text{ m} \approx 1: 1.5$$

$\therefore$  The proportional ratio of the pointed arch  $\approx$  1: 1.5.

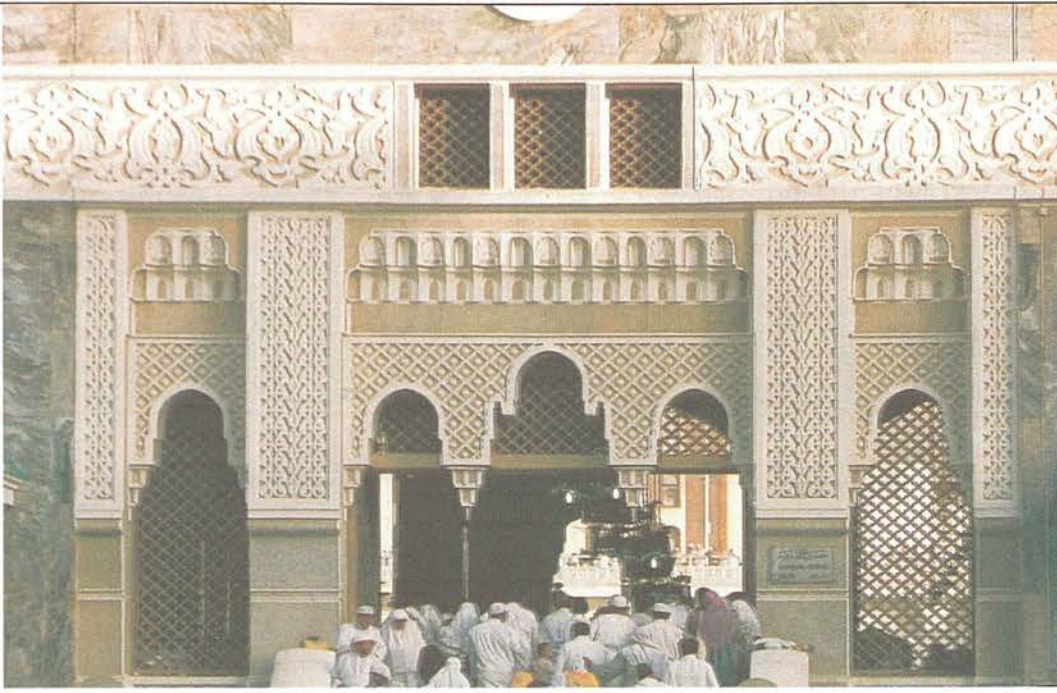


Fig. A.4. The south gate arches of the *al-Masjid al-Haram* mosque, ranged along with muqarnas

Another example of the proportional ratio is the grouped muqarnas on top of the south gate arch, from the main section details (Fig. A.5). The span between the grouped muqarnas on top of the arch is 5.24 m, and the height of the group is 0.87 m. These measurements and section details have been taken from the Saudi Binladen Group office, the designer of *al-Masjid al-Haram* mosque. Therefore, the proportional ratio = length span of the grouped muqarnas  $\div$  height of the group.

Therefore,  $= 5.24 \div 0.87 = 6.022 \div 2 = 3.011\text{m} \approx 1: 3$

$\therefore$  The proportional ratio of the altitude to the arch  $= \approx 1: 3$

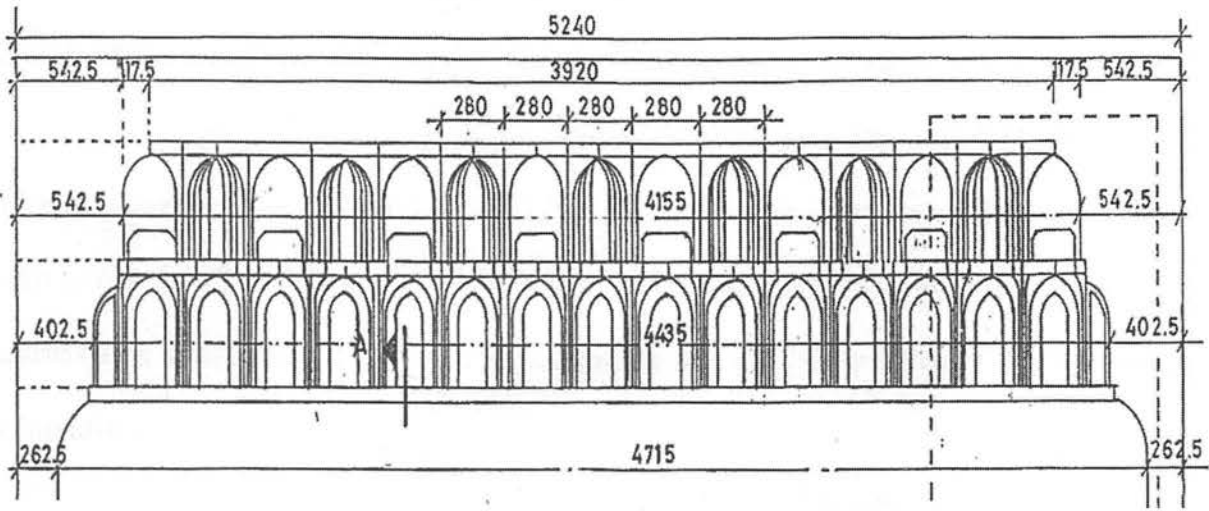


Fig. A.5. The main section details of the pointed with group of muqarnas on top of the south gate arch

In the axial point (Fig. A.6) the length of the arch in each muqarnas is 0.87 m, and the height of the arch in each muqarnas is 0.405 m. These measurements are taken from the Saudi Binladen Group office, the construction designer of *al-Masjid al-Haram* mosque.

Therefore, the overall proportional ratio in each muqarnas =

= length of the arch in each muqarnas ÷ height of the arch in each muqarnas

$$= 0.87 \div 0.405 = 0.248 \div 2 = 1.107\text{m} \approx 1:1.07$$

∴ The proportional ratio of each muqarnas arch  $\approx 1:1.1$ .

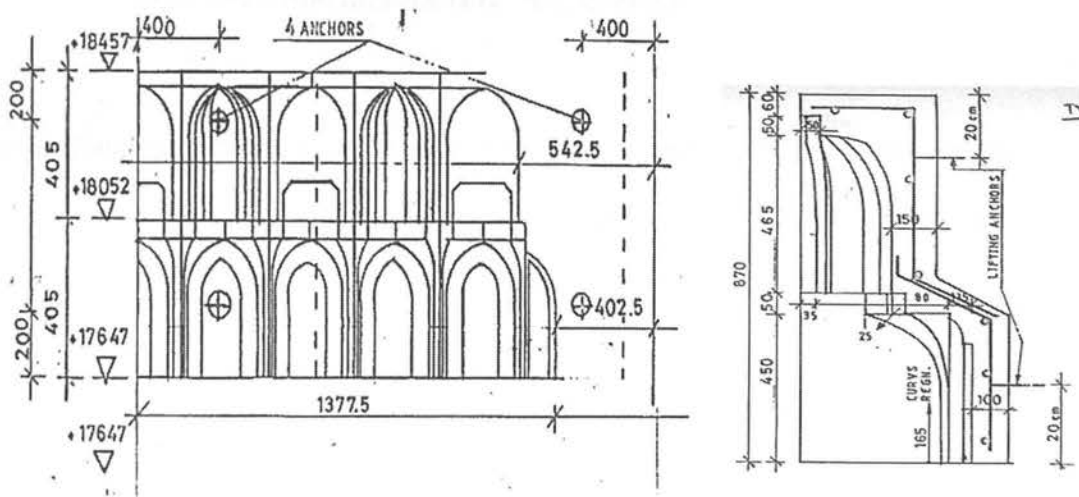


Fig. A.6. The section details of the arch in the whole and each muqarnas

From these proportional ratios of the round and pointed arches, of the same construction of the unit arch of the muqarnas, it is evident that the design of both arches reflects the ratios that are referred to in the epistles of *Ikhwan al-Safa*, discussed in Chapter Three, that Muslim artists and architects should apply in any architectural design. Studying these ratios of the arch units of the muqarnas has benefited and helped the author to reflect these ratios in this software design of the muqarnas arch units in the same way as they are applied in architectural design, as specified by the Muslim artist.

## 2.2. Capitals theme

The capital in architecture is defined as the top of the column. The muqarnas capitals are decorated with one, two or three tiers of muqarnas, with carved shafts on a column or pier, and a beam, arch, or vault around the capital. (The subject of capitals has been discussed in Chapter Two (pp.66–68), and also Chapter Three (pp. 152–154).) The proportional relationship between a capital and a muqarnas can be found in the example of the capital of the muqarnas in the *al-Masjid al-Haram* mosque, from the length of the total column (4.94 m), and the height of the capital (0.64 m). These measurements were taken by the author when he visited this site in January 2010 for the purpose of presenting this case study, and he confirmed them with the Saudi Binladen Group office, the designer of *al-Masjid al-Haram* mosque (Fig. A.7. a. to c.).

The proportional ratio between the length of the column and the height of the capital  
 $= \text{the length of the total column} \div \text{the height of the capital} = 4.94 \div 0.64 = 7.71 = 8$

Therefore, the proportional ratios of the height of the column to the length of the column capital =  
 $1:3$  ( $2 + 6 = 8$ ) and  $1 \times 2 = 2$  and  $3 \times 2 = 6$

$\therefore$  The proportional ratios of the height to the length of the column capital =  $2:6$ , which is =  $1:3$



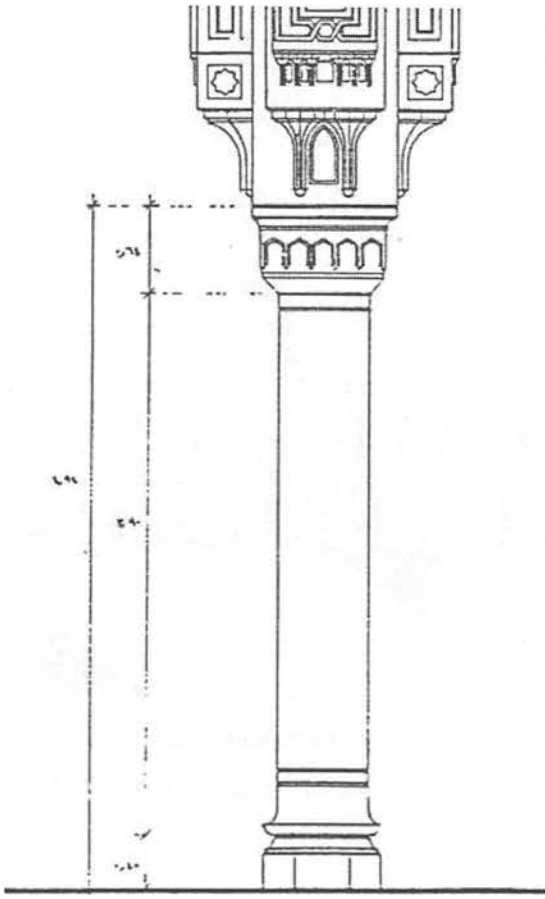


Fig. A.7.a. measurements details of column with muqarnas

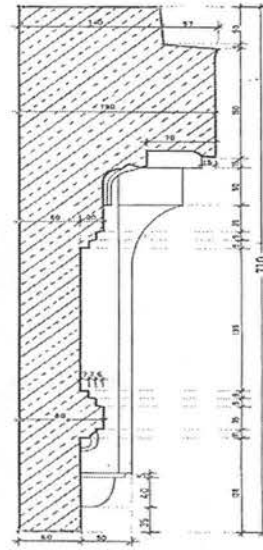


Fig. A.7.b. Section details of each muqarnas

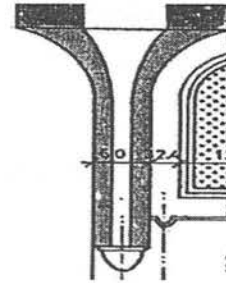


Fig. A.7.c. Section details of each muqarnas

Fig. A.7. (a. to c.) The measurements and section details of column with muqarnas capital and section details of each muqarnas.

By studying the capital of the muqarnas in the frustum of a pyramidal capital with a square outer form to circular inner form, it can be seen that the length of the square of the capital is (1.236m) and the height of each muqarnas of the capital is (0.21) m. These measurements and section details were taken from the Saudi Binladen Group office, the designer of *al-Masjid al-Haram* mosque (Fig. A.8. a. and b.).

The proportional ratio between the height of each muqarnas of the capital and the length of the square of the capital =  $0.21 \div 1.36 = 0.15 \approx 1: 1.1.5$

∴ The proportion of each muqarnas to the capital is  $\approx 1: 1.1.5$ .



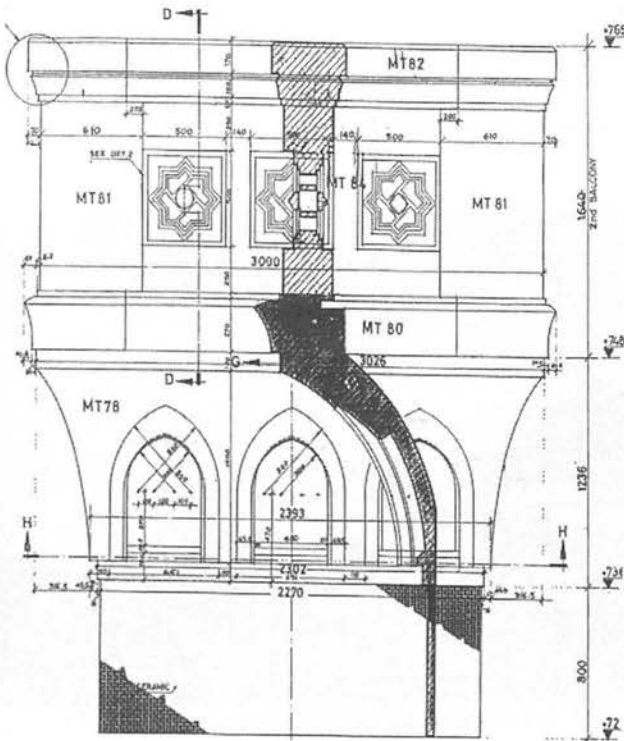


Fig. A.8.a. The section details of the capital

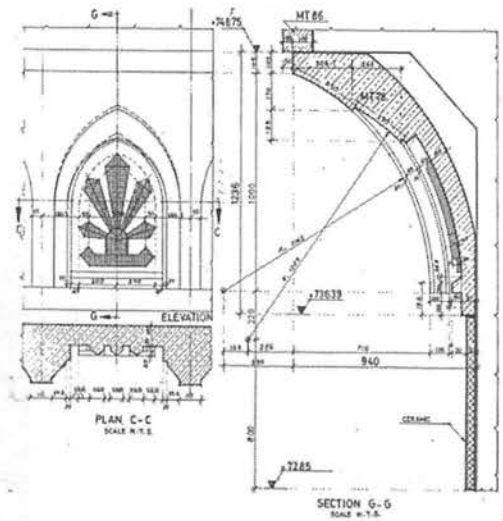


Fig. A.8.b. The section details of point arch in one unit of muqarnas

Fig. A.8. (a. to b). The section details of the capital with the section details of point arch in one unit of muqarnas

From this the author concludes that the two figures reflect the significance of the relationship between a single column, the capital and each muqarnas, the proportions which the author discusses in Chapter Three. These ratios are in line with those referred to by the Muslim artist that architects should apply in any architectural design. Also, they have helped the author to reflect these ratios in the design of columns and capitals with muqarnas using software.

### 2.3. Domes theme

The dome is defined as a piece of vault constructed on a circular, elliptical or polygonal plan. The constructed domes of the *al-Masjid al-Haram* mosque in Makkah have taken the square shape of the room and the circle shape of the dome. The muqarnas is used to hide the hard edge of the join between the square shape of the room and the circular shape of the dome. The proportional ratios of the dome are the foundation for the unity of the muqarnas and are illustrated by studying the projection sector for three massive domes, each 10 metres in diameter and 30 metres high (Fig.

A.9. b.). The photographs and measurements were taken by the author (Fig. A.9.a. to c.), when he visited this site in January 2010 for the purpose of presenting this case study.



Fig. A.9. a. The perspective view of the rooftop of *al-Masjid al-Haram* mosque.

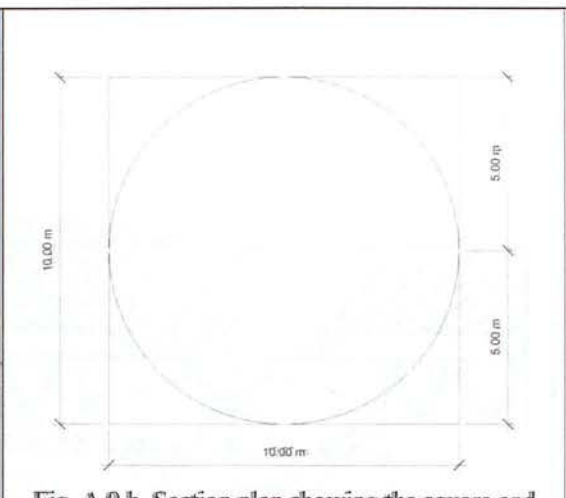


Fig. A.9.b. Section plan showing the square and circle shapes of the dome.



Fig. A.9.c. The reflected ceiling view of the dome's interior from west side domes

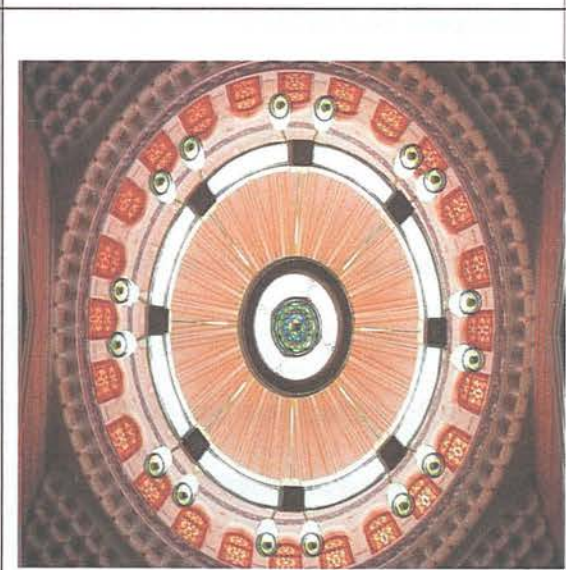


Fig. A.9.d. The reflected ceiling view of the dome's interior from centre

Fig. A.9. (a. to d.). The perspective view of the rooftop, and section plan showing the square and circle shapes, and the reflected ceiling view of the dome's interior in *al-Masjid al-Haram* mosque; photography and drawing by the author

Therefore, the total proportion of the dome = the diameter of the whole dome ÷ the height of the whole dome =  $10 \div 30 = 3 \text{ m} = 1:3$

∴ The proportional ratio of the dome  $\approx 1:3$

The author found the dimensions of the dome from the muqarnas construction designer of *al-Masjid al-Haram* mosque, and from the section details of the reflected plan of the muqarnas inside dome (Fig. A.10). The ratio of the rows of the muqarnas to the interior dome with the surface was approximately 1:3.

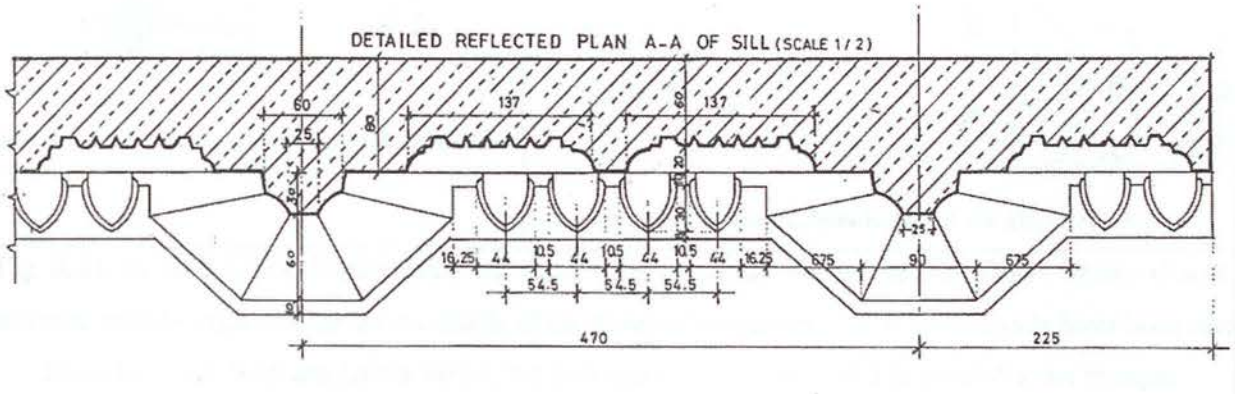


Fig. A.10. The section details of the reflected plan of the muqarnas inside dome with muqarnas. These measurements and section details have been taken from the Saudi Binladen Group office, the construction designer of dome at *al-Masjid al-Haram* mosque

Also, the author found, from the section details of the reflected plan of the muqarnas inside dome, and the section details of each muqarnas, and section details of the group of muqarnas (Fig. A.11. a. and b.), that the proportional ratios between the muqarnas rows and the lantern of the inner dome and the corner of the square of the outer form to the circular inner dome represent 1:3 approximately.



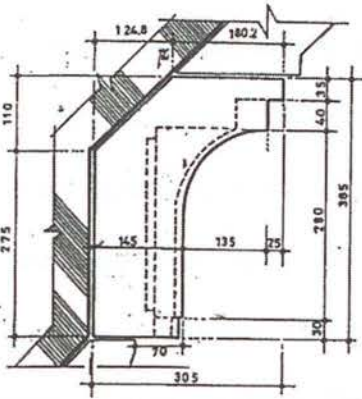


Fig. A.11.a. The section details of each muqarnas

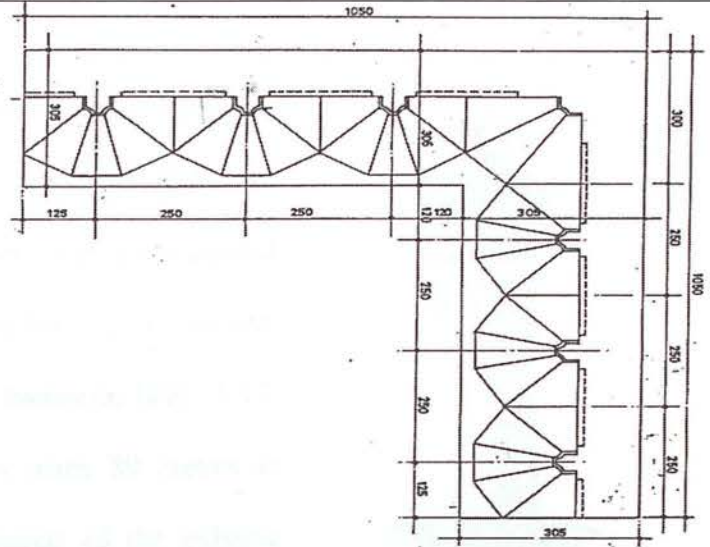


Fig. A.11.b. The section details of the group of muqarnas

Fig. A.11. (a. to b.). The dimensions of the dome with muqarnas. The left section shows details of each muqarnas, and the right section shows details of the group of muqarnas. The section details have been taken from the Saudi Binladen Group office, the designer of the dome at *al-Masjid al-Haram* mosque.

The author's interest in these ratios in the design of the muqarnas in the dome is to use the a single muqarnas in the inner of the dome edges and increasing rows different concepts, in order to apply these ratios in different dome designs with muqarnas using software.

#### 2.4. Minarets theme

Minarets are tall slender towers (circular, rectangular, octagonal, or polygonal in plan). The minarets of *al-Masjid al-Haram* mosque are square in shape at ground level, over an octagonal shape and then a circular shape on the top holding a crescent, attached to the mosque by two projecting balconies (Fig. A.12, photography by the author). The minarets reach 89 metres in height. Each is identical to the nine minarets of the existing mosque; the length of the side at ground level in each minaret 7.2 m; the length of side the octagon at shaft in each minarets 2.46 m. These measurements were taken by the author, when he visited this site in February 2010 for the purpose of presenting this case study, and are confirmed in the research of Shehate and Foda, (2004).



Fig. A.12. Minaret in *al-Masjid al-Haram* mosque, photographed by the author

Square area =  $w^2$  ( $w$  = length of side = 7.2 metre)

Square area of =  $7.2^2 = 7.2 \times 7.2 = 51.48$  square metre

The area of the octagon side at shaft =  $w^2 - 2b^2$  square metre (Fig. A.12). Since  $w = 7.2$  metre and  $b = 2.46$

$\therefore 7.2^2 - 2 \times 2.4^2 = 51.48 - 2 \times 5.76 = 39.96$  square metre

The proportional ratio between the length of square side at ground level and the height of the minaret = the total height of the minaret  $\div$  the length of the side of the minaret =

$= 89 \div 7.2 = 12.36$  which is approximately 12.

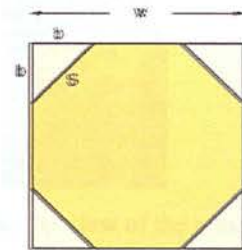


Fig. A.13. Section plan of the square and the octagon shapes side at shaft, drawing by the author

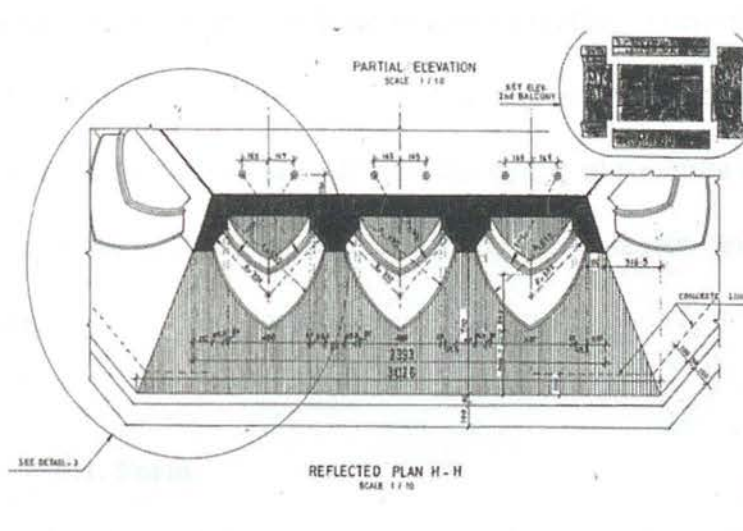
The proportional ratio between the length of the octagon side at shaft and the height of the minaret  
 = the total heights minaret  $\div$  the length of octagon side at shaft of the minaret =

$$= 89 \div 2.46 = 36.1 \text{ which is approximately } 36.$$

$$\text{Thus, } 12 : 36 \therefore = 1 : 3$$

Therefore, the proportional ratios of the square shape at ground level and the octagonal form of  
 each balcony represent:  $12 : 36 \therefore = 1 : 3$ .

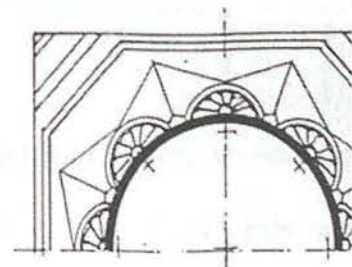
According to the principal ratios of the mosque height in terms of *al-Masjid al-Haram* mosque  
 (Fig. A.14), this shows the proportional ratios of minarets can be useful as the foundation for a  
 relevant study of the proportional ratios of muqarnas unity, which is:  $1 : 3 \approx$ .



A.14.a. The measurement section details of the construction design the minaret with muqarnas



A.14.b. The top view of the minaret



A.14.c. section plan of the minaret

Fig. A.14. (a. to c.). The measurements and section details of the construction design of the minaret with muqarnas, and section plan of the minaret, taken from the Saudi Binladen Group office, the designer of *al-Masjid al-Haram* mosque



The author's interest in these ratios in the design of the muqarnas in the minaret is to use the different concepts of the shapes of minarets, e.g. square, octagonal shape and circular, in order to apply these ratios in different minaret designs with muqarnas using software.

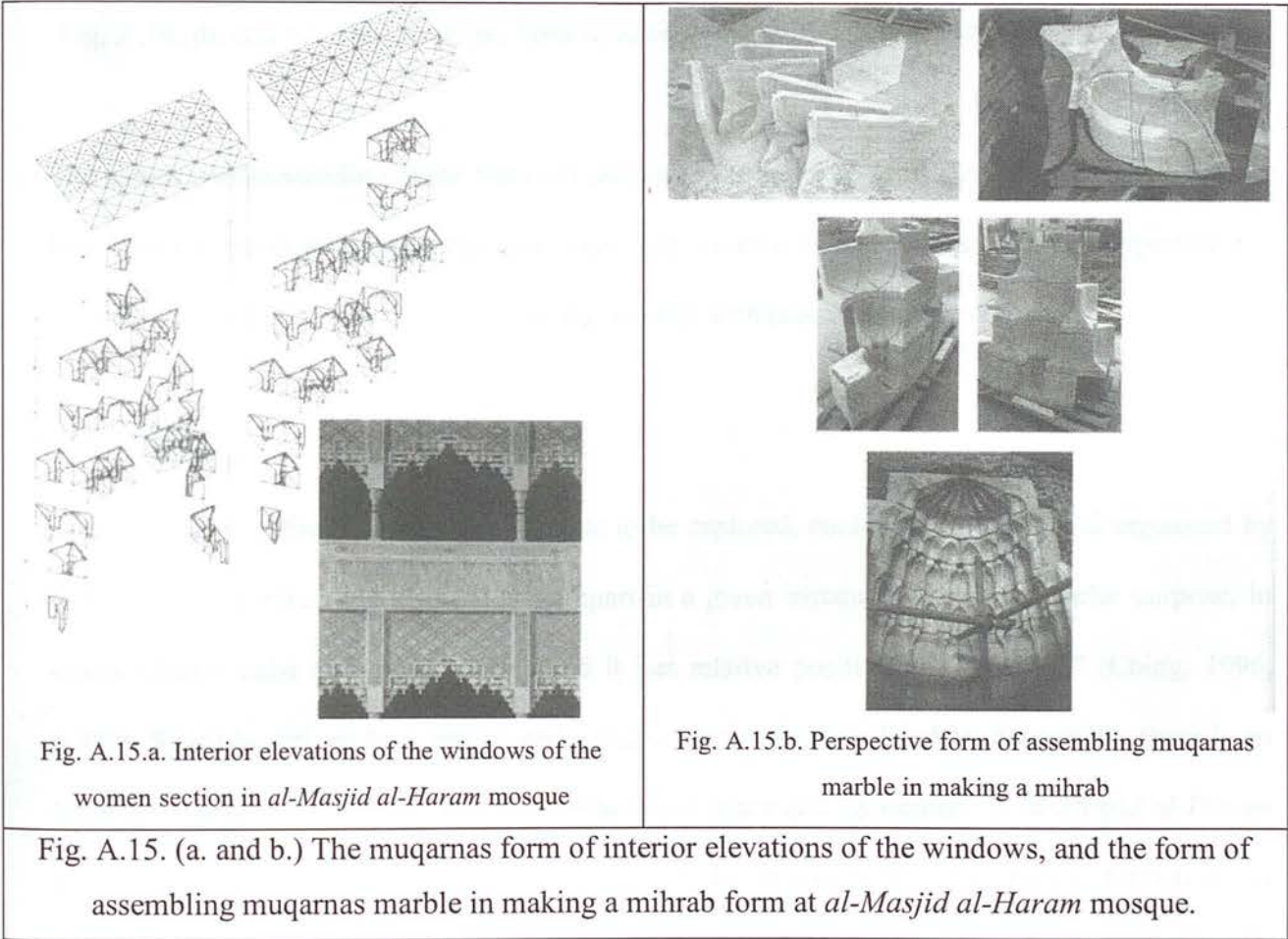
### 3. The identity of the muqarnas examples

The identity of the muqarnas in *al-Masjid al-Haram* mosque comes from maintaining the surface structure through ornament and geometry, and also from its functions and roles which are an expression of laws embedded in the deep structure. It has a cultural, consistent, meaningful and symbolic role, which conveys a persistent religious message that Islamic works of art express in aesthetic terms. The core of that message is consistency and charm in the elaborate epigraphic carvings. The subject of the identity of the muqarnas has been discussed by the author in Chapter Four (pp. 207–209). However, more attention has been paid to the *al-Masjid al-Haram* mosque in Makkah, as the most significant religious building, where the muqarnas is expected to be seen as contributing to the architectural and artistic experimentation of mosques everywhere. This case study now attempts to identify how the notion of structure incorporates a number of key ideas in terms of form, space, ornament, hierarchy, wholeness, unity, aesthetics and symbolism of this mosque.

#### 3.1. Form

Form has been defined as the point of contact between mass and space, emphasising two phenomena that are related to each other (Ching, 1996, p.34). In *al-Masjid al-Haram* mosque in Makkah the forms of the muqarnas are the result of the interrelationships between structural and ornamental functions. The geometric design and numerical system have used lines, circles, triangles, squares, rectangles, pentagons, hexagons and polygon. In this respect, the use of numbers to plan geometric or available space is vital for the repeat muqarnas designs. Colour, texture, position, orientation, visual interior and exterior are used to produce a coherent effect in

the science of architectonic forms and to create the magnificence of the everlasting beauty of the muqarnas in *al-Masjid al-Haram* mosque. When the author visited the mosque in January 2010, he was impressed with the richness of the muqarnas forms, which are linked between mass and space and are related to each other. Therefore, he has addressed the issues of muqarnas forms in the *al-Masjid al-Haram* mosque, to cover important functional and material aspects, such as the form of the interior elevations of the windows in the women section of *al-Masjid al-Haram* mosque, which were made by *Mac-Joe* woods (Fig. A.15.a), and the form of assembling muqarnas marble in making a mihrab (Fig. A15.b, photograph by the author).



The following illustration emphasises the muqarnas phenomena that are related to the exterior view of the minaret (Fig. A.16.a), and interior view of the dome (Fig. A.16.b). The author visited this place and the photographs were taken by him in January 2010.





Fig. A.16.a. Exterior muqarnas view with minaret



Fig. A.16.b. Interior muqarnas view with the dome

Fig. A.16. (a. and b.). The muqarnas form of exterior and interior view at *al-Masjid al-Haram* mosque

The author's understanding of the forms of muqarnas design in *al-Masjid al-Haram* mosque, and how it merges form with space, has also helped him to develop the exploratory and interpretative features to create different three-dimensional themes with muqarnas using software.

### 3.2. Space

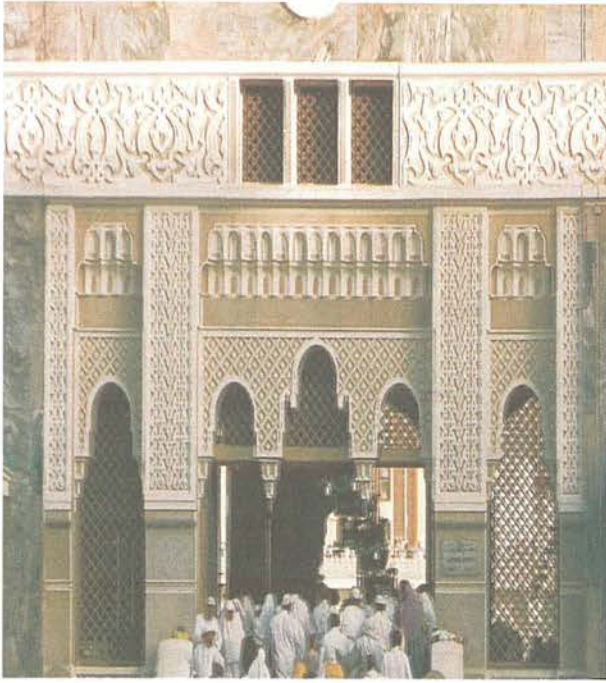
Space has been defined as that which begins to be captured, enclosed, moulded, and organised by the elements of mass, and also, "it is set apart in a given instance or for a particular purpose, in which objects exist and events occur, and it has relative position and direction" (Ching, 1996, p.382). Space is defined by surfaces and, since a surface is articulated by decoration, there is an intimate connection in Islamic architecture between space and decoration. In *al-Masjid al-Haram* mosque in Makkah the muqarnas is considered to be an extension of geometric formations in space which assist in the transition between the square, circle and octagon. The relationship of space to shape is perceived in distinct levels of interaction. The muqarnas is viewed as an active shape bounded by a positive space. Moving within the three-dimensional mass of positive spaces creates interactions with negative, passive shapes. Through the use of geometry and mathematics, a vital positive space carves a hierarchy of negatives. The muqarnas in *al-Masjid al-Haram*

mosque is viewed as an active quality of positive space carving a spatial connection that flows rapidly through the transition. The subject of space has been discussed in Chapter Four (pp.190 – 191).

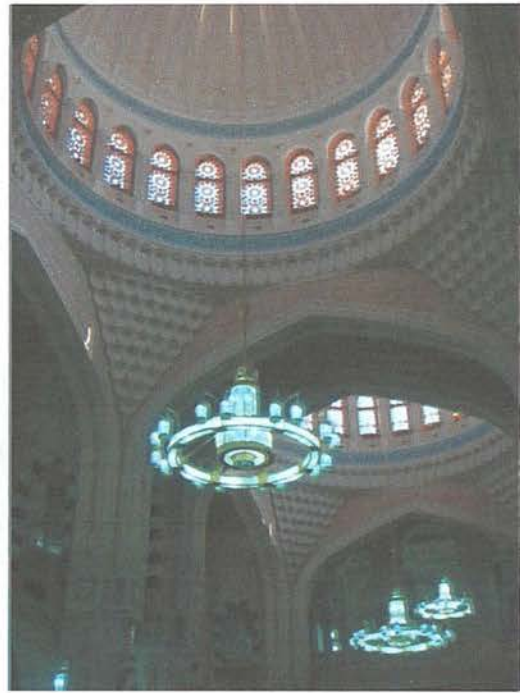
The spaces in *al-Masjid al-Haram* mosque consist of beautiful artistic components of diagonal lines for the flexures, curvatures, refractions, intersections and overlapping formations of the muqarnas. These components are interrelated, by either differentiating an elementary spatial unit – the niche – into a multiplicity of related smaller forms, or by bridging step by step the subdivisions between individual smaller units and thus reconvertting multiplicity into unity. The harmony and the sense of unity of a building can be enhanced by relating all the different parts to the same “generative unit” by means of a limited number of geometrically determined proportions (Wilbrun, 1955, p.140).

The idea behind the use of proportions in *al-Masjid al-Haram* is that the ideal system of beauty which permeates nature can be expressed by allocating space in conformity with predetermined proportions. The main aim of this investigation is to develop the different functionality, in creating a form that follows the function of the space, so that the author can develop software that is compatible with elements of mass in the space system. That feeling came to the author when he visited this place and took the photographs in January 2010 (Fig. A.17. a. to d.).





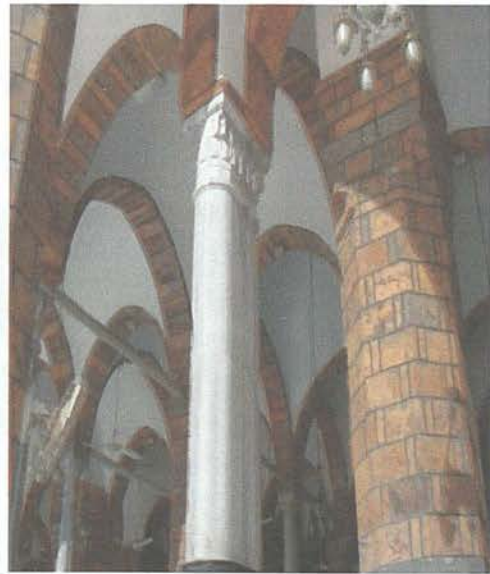
A.17.a. Exterior space of the entrance of the southeast gate of *al-Masjid al-Haram* mosque



A.17.b. The interior space of the dome with muqarnas reflection



A.17.c. Muqarnas geometry formations in space effected on the top of the arch reflected inside *al-Masjid al-Haram* mosque



A.17.d. Muqarnas geometry formations in space effected on the capital of the column reflected inside *al-Masjid al-Haram* mosque space

Fig. A.17. (a. to d). The muqarnas geometry formations in space at *al-Masjid al-Haram* mosque.

### 3.3. Ornament

Ornament consists of decorative objects or designs added as an embellishment to another object. One of the most remarkable features of the Islamic tradition is the predominance of ornament, which has played a role in interior and exterior decoration in Islamic architecture, whether religious or civic. Islamic ornament produced on a plane aims to exist on that particular plane and not extend beyond it. Throughout the Islamic ages this has produced a unique sense of divine beauty and tranquillity which has no other example in human history. One of the unique ornamental structures in Islamic architecture is the muqarnas, the structural and ornamental functions of which are a result of the productions of natural objects preserving their intrinsic structure and characteristics in Islamic art. In *al-Masjid al-Haram* mosque geometric ornamentations were established upon the repetition of certain geometric units. This started as a simple composition of lines forming interlacing spaces, and then become more complicated, creating endless compositions through the combination of geometrical shapes with different proportions. The author focused on the harmony of ornamental function when he visited this place and the photographs were taken by him in January 2010 (Fig. A.18. (a. to d)).

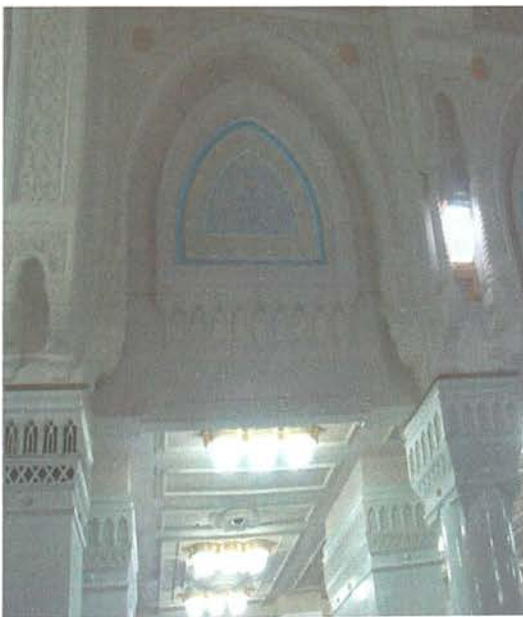


Fig. A.18.a. The design shape of the muqarnas as a structural and ornamental function, in arches capitals, cornices, cantilevers and façades



Fig. A.18.b. Transitions inside the Holy Mosque corridors by treating muqarnas arches between the columns, cornices, cantilevers and façades



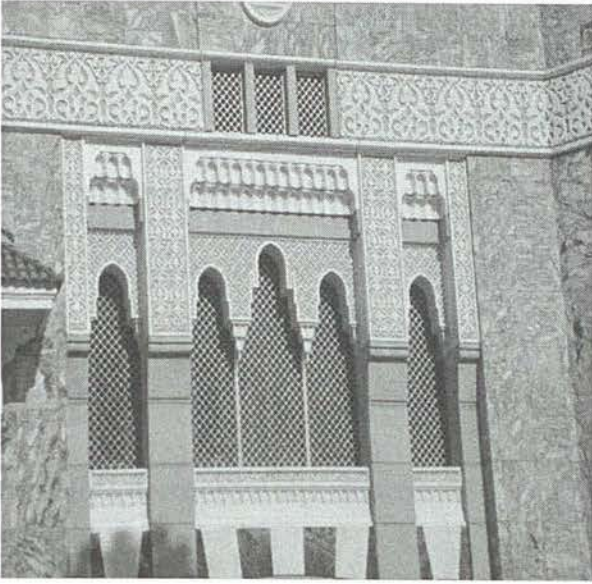


Fig. A.18.c. Shading device of treating muqarnas on the top of the arches in windows and cornices.



Fig. A.18.d. The joint between two arches is treated by muqarnas on the capital of the column

Fig. A.18. (a. to d). Ornament with muqarnas in *al-Masjid al-Haram* mosque

### 3.4. Hierarchy

Hierarchy has been defined as a system of elements ranked, classified and organised one above another, according to importance or significance (Ching, 1996, p.381). The structure is influenced by the ordered relation of parts to a whole, being arranged in a manner in which the components are connected together. According to this order, a component of a structure can be understood by integrating it into the higher-order structure. Structuralists always see hierarchy as the mutual subordination and superordination of components in a state of constant regrouping. The subject of hierarchy has been discussed in Chapter Four (p.198).

The principle of hierarchy that applies in the muqarnas of *al-Masjid al-Haram* mosque means that each level is different from the level above and the complexity increases, until it reaches the ultimate object, the organism, which has an identity as a whole. This identity is formed from such a hierarchy, where each level is more complex than the one below it. Its principles of subdivision and integration are interdependent aspects of a total architectural composition, which emphasises

both autonomy of single elements and the inclusion of individual units in larger ones. The result is a perfect balance between the “part” and the “whole”. The concept of hierarchy in the muqarnas can be related to the different rules in architecture and decoration of the elements of *al-Masjid al-Haram* mosque, such as treating the muqarnas on the end of the arch by translating the Shami-type shape from three to one (up to down) (Fig. A.19.a.), or treating the capital of the column by translating the Shami-type shape from one to three (down to up) (Fig. A.19.b.), or approaching from the Shami type and Baladi type by merging them together (Fig. A.19.c.). The author got alternative decorative elements of the muqarnas, by sequences of hierarchy to beauty as being in balanced harmony between design shapes. This attraction came to the author when he visited the Holy Mosque and took the photographs, in January 2010. The author’s interest in this hierarchical system enabled him to apply it in different muqarnas designs using software.

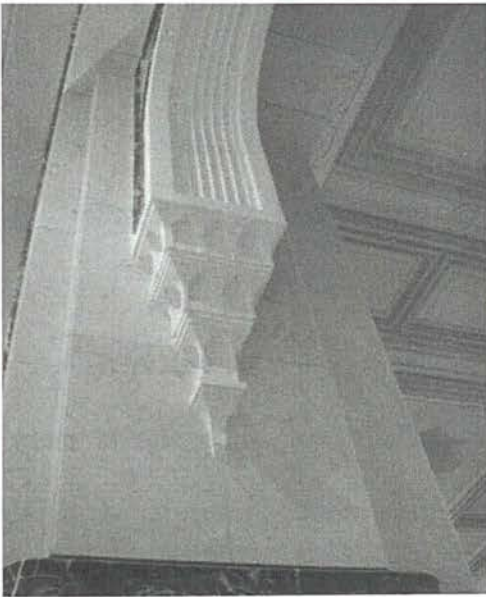


Fig. A.19.a. Treating muqarnas at the end of the arch by translating the Shami-type shape from three to one



Fig. A.19.b. Treating the capital of the column by translating the Shami-type shape from one to three



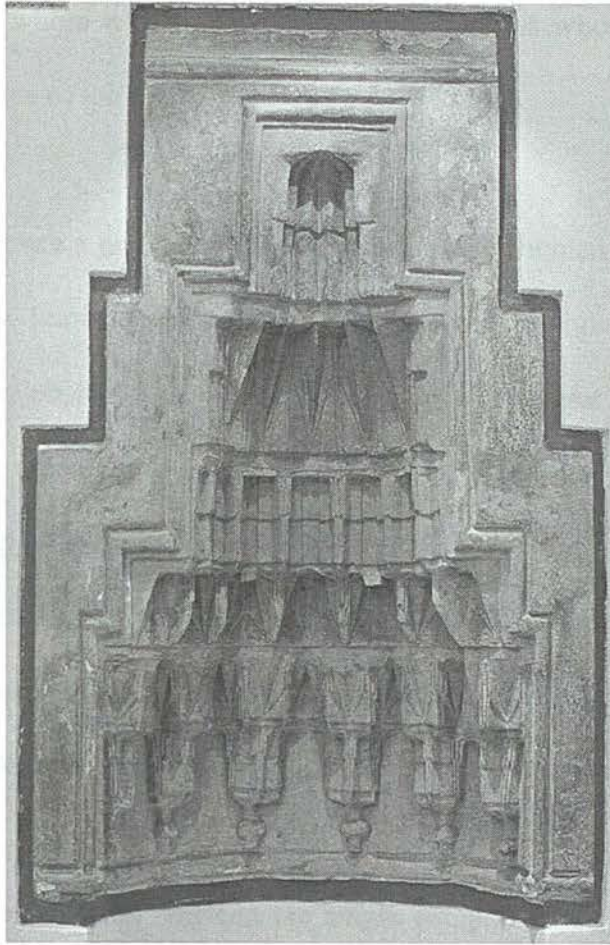


Fig. A.19.c. Approaching from the Shami type and Baladi type by merging them together at mihrab.

Fig. A.19. (a. to c). Hierarchy of muqarnas in *al-Masjid al-Haram* mosque

### 3.5. Wholeness

Wholeness is one of the most significant characteristics of the structure. Wholeness can be considered as “an assemblage of parts associated or viewed together as a single object; a unitary system; the whole assemblage of parts or elements belonging to a thing; the entire quantity, account, extent, or number; a thing complete in itself, or comprising all its parts or elements” (The American Heritage Dictionary, 2004).

Structuralism attempts to grasp reality as a whole, in which part and whole are seen simultaneously. It is the whole that gives the part its defining characteristics in that physical situation. According to Piaget (1971, p.8), a structure (in the most general sense) exists when

elements are united in a whole which presents certain properties whose elements are wholly or partially dependent on those of the whole.

The objects of Islamic art are a comprehensive and meaningful human environment, leading to a sense of responsibility in human development, by combining architecture, interior decoration, furniture, books and many objects of daily use. Islamic art emphasises the notion of unity in that all the elements together create an architectural form. The muqarnas ornament in *al-Masjid al-Haram* mosque is the shaped linear decorations of the surfaces, with ornamentation being a system of such elements, whereas ornamentation comprises the reaction of the form of the ornament to the surface on which it appears, or is a specific organisation of tectonics in space, which means that each unit is not independent, but depends on the rest, and is connected through that wholeness.

The author is interested by the link between the single component and the whole elements, and between the wholeness and the single component, which emphasises the notion of unit in the element through the created muqarnas. He tried to apply these units such as Shami and Baladi types in different muqarnas designs using these same concepts in his software. The author has visited this place and the photographs were taken by him in January 2010 (Fig. A.20.a. and b.).



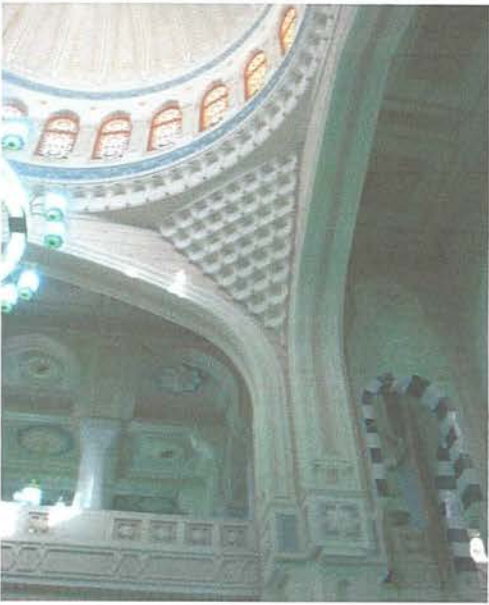


Fig. A.20.a. Transitions of the muqarnas from the dome to the join between the arches to the end of the capital of the column



Fig. A.20.b. Transitions outside the Holy Mosque façade, treating muqarnas in whole assemblage of parts or elements belonging to column, arches, capital, cornice and so on

Fig. A.20.a. and b. Each unit in *al-Masjid al-Haram* mosque is not independent, but depends on the rest, and is connected through that wholeness

### 3.6. Unity

Unity is considered one of the most outstanding characteristics of Islamic architecture, and it is the fundamental principle in Islamic philosophy and spirituality. It forms the basis of styles of Islamic art, which emphasises the notion of unity such that all elements together create an architectural form, including space, shape, light, colour, and matter, rejecting sharp distinction between secular and sacred architecture (Nasr, 1971, pp.19–37). The subject of unity has been discussed in Chapter Four (pp. 220–222).

This unity remains a basic component of the identity of Islamic architecture. It is true that places of worship such as *al-Masjid al-Haram* mosque, for instance, have departed from that principle of unity in that a great variety of architectural styles is present. But this is evidence of the role of creativeness in enriching architectural design. It also denotes the consistency of architecture with its overall architectural, social, and cultural environments. Variety within unity is one of the

distinguishing features of Islamic architecture, revealing a strong disposition to develop, innovate, and create.

The function of the “organic” unit can be distinguished at various levels, such as the double use of the muqarnas, structural and ornamental, that is used for a multiplicity of purposes. The muqarnas usually takes the form of a staircase which comprises three cross vaults which create two barrel vaults side by side, with the third on top, divided into grades in the same proportion as the structure of the graded axis. *Al-Masjid al-Haram* mosque is characterised by the variety of its styles and forms of such muqarnas units (e.g. arches, domes, capitals, windows, ceilings, minarets, minbars, and façades).

The author has benefited from exploring these styles of muqarnas, such as Shami and Baladi types and stalactites, through the different parts of the architecture in *al-Masjid al-Haram*. He used these types to guide the contents of the muqarnas generator program. The author has visited this place and the photograph was taken by him in January 2010. (Fig. A.10.a. and b.).



Fig. A.21.a. The wall-mounted muqarnas of the Baladi type on the details of the side view of the capital of the column



Fig. A.21.b. Muqarnas shapes (sculptured) on the capital of the column

Fig. A.21.a. and b. The unit of muqarnas of *al-Masjid al-Haram* mosque



### 3.7. Aesthetics and symbolism

Aesthetics and symbolism play a very important part in the Islamic arts and they are based on spiritual values or ideal Islamic behaviour, with deep roots in religion. Islamic art is founded on the twin doctrines of faith and beauty. A saying of the Prophet Muhammad (Peace Be Upon Him) mentions that {God is beauty and He loves beauty}. Faith was the driving force that influenced the early Muslims to beautify their environment. The subject of aesthetics and symbolism has been discussed in Chapter Four (pp. 214–217).

One of the deep roots in design has been the aesthetics of the creation of buildings. As it concerns harmony and configuration, bringing together all the elements of composition and proportion, aesthetics has led to the surfacing of the muqarnas as an aesthetically interdependent formation.

The combination of Islamic architectonic and muqarnas forms should be regarded as the most important element in Islamic art, for when the symbols and principles are proportionately balanced, the equilibrium usually creates a beauty and perfection that would not otherwise be possible. In other words, surface structure represents the building of the muqarnas itself, its ornamentation and decoration, and all the visible aspects. Deep structure represents the meaning and the forces responsible for producing a particular design in a particular place, as expressed in its Islamic architectural and artistic contexts, and its subjective meaning as represented in various cultural, sentimental and symbolic values.

Moreover, the deep symbolic form of the muqarnas is identified with the symbolic form of a less concave niche or a small mihrab, which has different sentimental meanings, such as veneration of place, a feeling that is inviting but demands discretion, signifying a door opening onto the divine world and passing through to an otherworldly experience.

In *al-Masjid al-Haram* mosque, the adoption and application of a model which combines the Word of God, geometrical expressions and repeat decorative verses or patterns in the architecture produces a system of architectonic forms. Thus the muqarnas attracts our perception through the immediate sensible beauty and attraction between lines and arches in the formation, which we can feel, think and be aware of through their shaping and the creativity in the diversity of forms, depending on different designs of muqarnas and the use of different types of muqarnas. The author always used to visit this place and he decided to undertake research related to the beauty of muqarnas. It also sparked his curiosity in order to develop further and extend his experience in this important area (Fig. A.22.a. and b., photograph taken by the author in January 2010).



Fig. A.22.a. Complication of the shape of the muqarnas from the edges to the end point of Ibrahim Gate (portal), by mixing between Shami, Baladi and Stalactite types



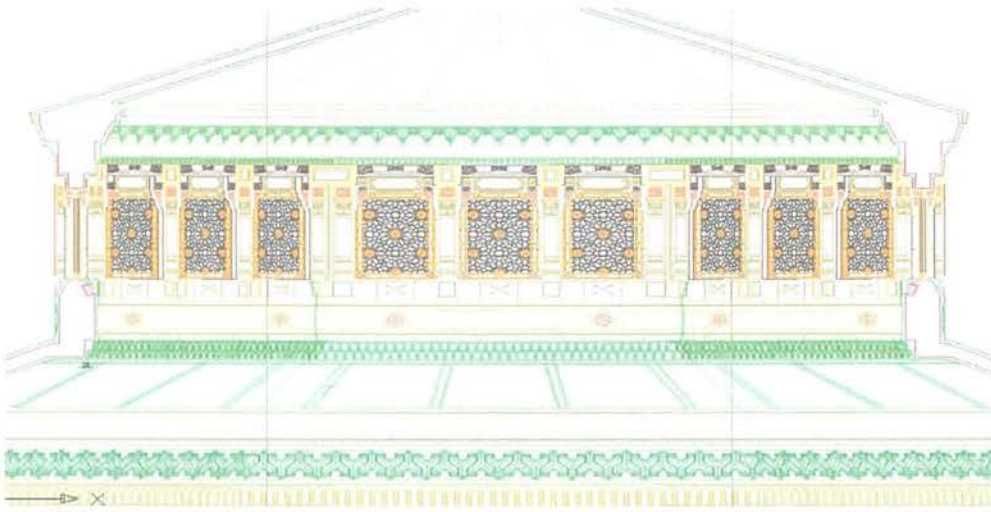


Fig. A.22.b. The section plan of the interior elevation of *al-Safe* and *al-Marwa*, in *al-Masjid al-Haram* mosque. This section details have been taken from the Saudi Binladen Group office, the construction designer of dome at *al-Masjid al-Haram* mosque

#### 4. Conclusion of case study

This case study has given the author the opportunity to demonstrate the various important aspects of the muqarnas discussed in the thesis, especially with reference to proportion order and identity, as well as demonstrating the various hidden and philosophical dimensions that are expressed. This was done by examining the use of the muqarnas in *al-Masjid al-Haram* mosque from the point of view of identity in relation to the proportional features of arches, capitals, domes and minarets, and exploring the deeper aspects related to the meaning and symbolism of the muqarnas, particularly its connection to form, space, ornament, hierarchy, wholeness, unity, aesthetics and symbolism, and the expression of all these within Islamic art and architecture. It has also shown that the physical features of the muqarnas are used widely to express the identity associated with history and religious buildings.

In particular, the case study has shown that the muqarnas is a more complex and rich phenomenon than appears to us in the process of observing and enjoying the muqarnas as a feature. The author hopes that showing all this in relation to *al-Masjid al-Haram* mosque will add to the other contributions made by this thesis.